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ABSTRACT

Intended for use in conjunction with guidance and instruction from a teacher or tutor, this guide provides an overview of the philosophy of quality as well as some tools used in business and industry today. Each of four sections consists of a teacher explanation of the topics followed by student worksheets with annotated teacher keys. The first section, on the philosophy of total quality control, begins with a discussion of two quality experts--Juran and Deming. The concepts of total quality control, teamwork, and group problem solving are discussed, and some related activities are included. The statistical tools section covers check sheets (probably the most frequently used statistical tool), Pareto charts, histograms, and control charts. Each tool is introduced to the instructor first. Sampling, central tendencies, and dispersion are explained before instructors present the concepts to students in the form of worksheets. The math section contains math-related concepts needed to read, interpret, and create various charts and graphs. It includes a brief discussion of "mental math," calibrations, and the "Percent Circle." The appendix provides supplemental examples of various tools of quality for use if the teacher has difficulty finding workplace materials from his or her own workplace. The game of BEANO is included for vocabulary building. Other contents include a glossary and five references. (YLB)

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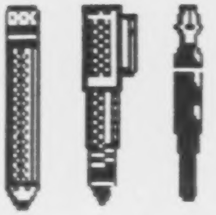

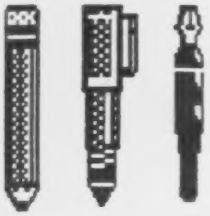

QUALITY
QUEST

A Guide to Total Quality Control For Workplace Education Instructors

Developed and Written By
Donna Curry and Nancy Kirk
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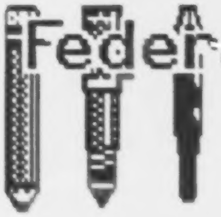
Funded By a Grant From
Federal Dept. of Education



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INTRODUCTION

Our intent is to provide an overview of the philosophy of quality, as well as some of the tools used in business and industry today.

The aim of this guide is not to replace teacher instruction. Our intention is that it be used in conjunction with guidance and instruction from a teacher or tutor. We have only provided sample work sheets to be used by teachers as guidelines for developing their own work sheets and activities.

The most effective teaching of quality concepts and statistical tools is through real-life situations. We urge you to use specific work-related materials whenever possible. Learn what the philosophy of quality is in the organization in which you are working. Incorporate the organization's quality goals and perceptions of teamwork into your classroom setting.

If you would like support in initiating your own workplace quality curriculum, please feel free to contact either one of us. We would also enjoy hearing comments from you regarding our curriculum materials.

If you would like more copies of this guide, contact Bob Bozarjian at the Bureau of Adult Education 1385 Hancock St. Quincy, MA 02169.

Thank you,

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THIS GUIDE

We have divided this guide into four sections. Each section consists of a teacher explanation of the topics. Following the teacher explanation are student work sheets along with annotated teacher keys. For ease of use, the student work sheets are all bordered. Our intent is for you to freely copy student pages.

Philosophy: The Philosophy section begins with a discussion of two quality gurus: Juran and Deming. The concepts of total quality control, teamwork, and group problem-solving are also discussed. Some activities related to teamwork and problem-solving are included for setting the stage for further work in quality concepts.

Statistical Tools: The Statistical Tools section covers a wide variety of topics. Check sheets, probably the most frequently used statistical tool, as well as Pareto charts, histograms, and control charts are included. Each tool is introduced to the instructor first. Any special concepts are also introduced: sampling, central tendencies, and dispersion are explained before instructors present the concepts to the students in the form of work sheets.

Math: We felt some math review was needed as part of the guide, but we were unsure of where to place it so that it would be readily accessible. We have not provided you with the typical math review found in most workbooks. Instead, we have chosen math-related concepts needed to read, interpret, and create various charts and graphs. We have included a brief discussion on 'mental math', calibrations, and the Percent Circle. Depending on the level of your students and depending on the statistical tool you are using, you may want to refer to the section on math.

Appendix: We included supplemental examples of various tools of quality here. Use them if you have difficulty finding workplace materials from your own worksite. We also included BEANO to use for vocabulary building.

Glossary: A glossary of terms used in this guide is provided at the end. We attempted to define the terms from an educator's viewpoint rather than a statistician.

Bibliography: The annotated bibliography consists not only of reference materials that we have used in developing this guide, but also other materials that we thought would be of interest to you.

QUALITY
QUEST

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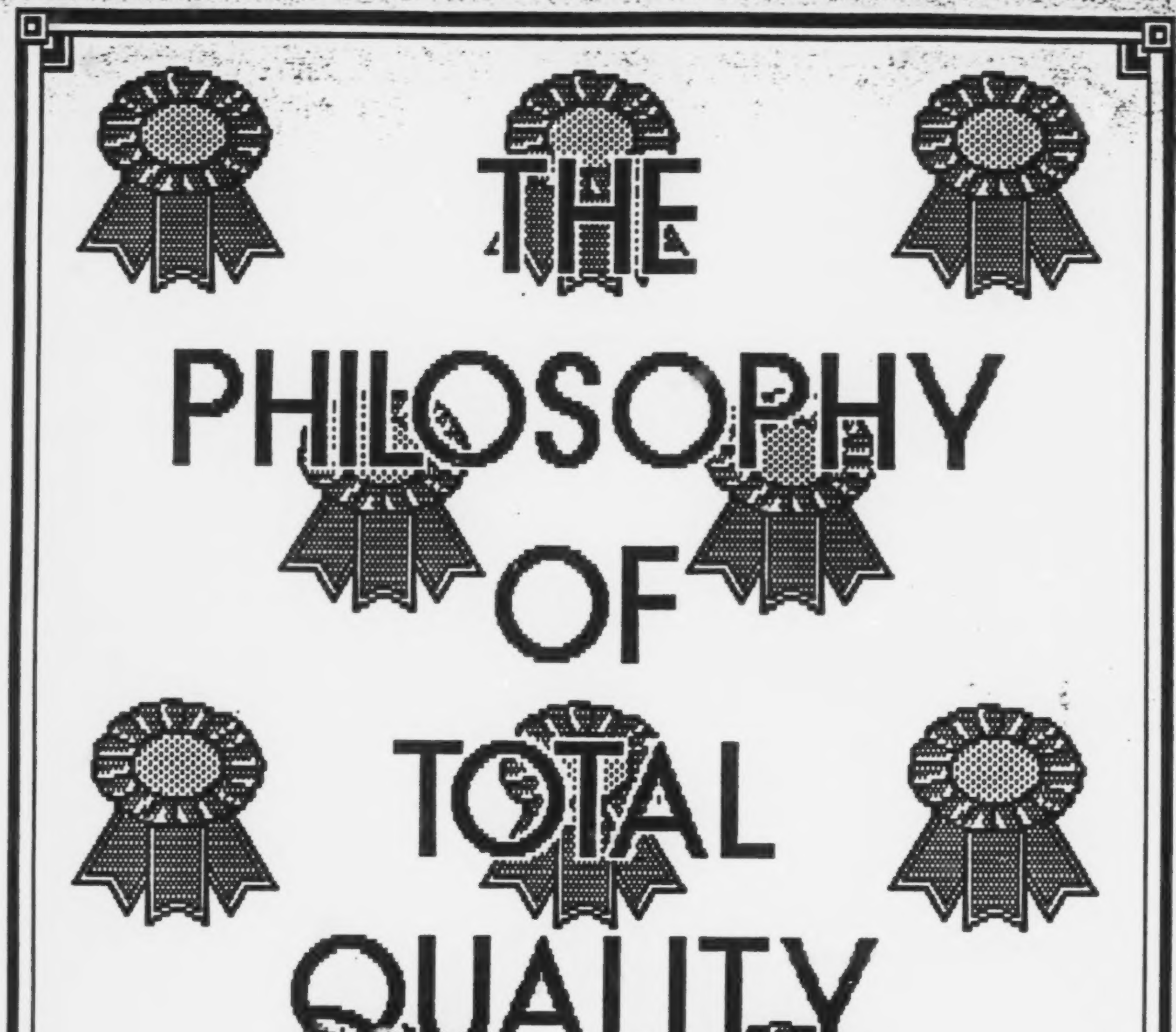


THE PHILOSOPHY OF TOTAL QUALITY CONTROL

PHILOSOPHY

Two Americans, W. Edwards Deming and J. M. Juran, were key players in helping Japan overcome its economic crisis in the early 1950's. At that time, it seemed that no one in America was interested in listening to their suggestions for improving productivity and building quality into manufacturing processes. Japan, on the other hand, was desperate and willingly accepted their theories for improving quality. The results of Japan's quality revolution can clearly be seen as you drive down the street or operate such home appliances as your microwave or VCR.

Deming took a very simple idea and built an entire philosophy of quality around it. He said that quality costs less if it is designed into a process rather than seen as an afterthought when the process is complete. As quality is built into the process itself, the cost of rework and scrap goes down and profits go up.

One of his famous "14-Points" states that we need to "create consistency and continuity of purpose". Deming believes that in order to survive, we have to be in a state of continuous improvement, always striving to create a better process or product, always looking to the future. As a mathematician, he believed that statistics could be used to monitor processes so that improvements could be made. Today that theory is incorporated into the methodology of statistical process control, used by many organizations.

Many of Deming's 14 points deal with management and labor relations. He suggests that we do away with incentives and bonuses because it creates competition among employees. Also, employees tend to work for the external rewards rather than for the good of the company, for the internal reward of having created a quality product. All employees should work together as a family unit to ensure quality.

This is in direct opposition to Juran's theory that employees should be rewarded. He believes that rewards should be built into the planning process itself. At the same time that quality goals are established and strategies are designed to work toward those goals, a system for rewarding individuals should also be established. A rewards system should not be an afterthought to the quality planning process.

Both Deming and Juran believe that goals must be established before an organization can expect quality to occur. Each organization must establish quality goals and then strive to reach them. Juran suggests a three-step feedback loop: evaluate the present quality performance, compare it to the organization's quality goals, and then act on the difference between the two.
According to both Juran and Deming, there should be more team effort used to solve problems. Also, all employees should be aware of what they are doing - how they fit into the bigger picture. Both agree that all employees should have amply opportunities to develop and grow.

Both believe that quality must involve everyone, from the president of the organization on down to the workers on the floor. Quality cannot be mandated or required. It is a state of mind, an attitude about how the work gets done.

STRIVING FOR TOTAL QUALITY CONTROL

Total quality control is striving for quality in all aspects of an organization. It is not a program that can be bought and implemented. It is a philosophy, an approach to managing an organization.

TOTAL QUALITY CONTROL involves the **TOTAL** organization in sharing a commitment to provide **QUALITY** products and services by **CONTROLling** the processes of an organization. Several components are essential for any organization striving toward total quality control.

Employee Empowerment: The total organization must be involved, the workers as well as management. Decisions should not just be mandated by the "powers that be"; instead, there should be involvement by all those that are affected. Quality circles, small group improvement activities, and team processes are examples of employee involvement. Fresh ideas come out of such groups because employees feel they are a part of the organization. This empowerment provides not only a sense of belonging and involvement, but also a sense of worth.

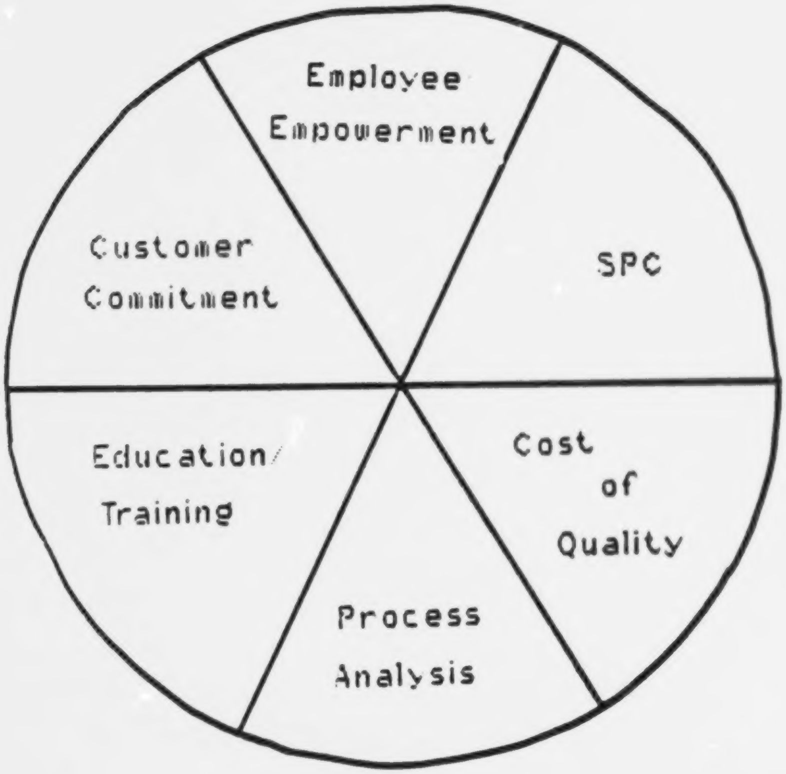
Customer Commitment: Knowing what the customer wants is critical to an organization. Without customers, there is no business. An organization should continually be sensing its customers to provide the best possible product and/or service.

Education/Training: In order to offer quality products and services, an organization must continuously improve. This continuous improvement comes about only through on-going education and training. The organization that does not consider continuous improvement as one of the critical components to total quality control will soon be out of the competition.

Process Analysis: When employees treat each other as 'customers', quality products and service follow. Each worker should be aware of who his/her 'customer' is. This awareness leads to communication about the process flow and the quality of the product being forwarded down the line.

Cost of Quality: It would probably be more appropriate to call this component the 'cost of not having quality'. An important consideration in total quality control is looking at the effect of not providing a quality service or product. Often products that are poorly manufactured must be reworked or scrapped. Both cost money. Between 20 - 30% of revenues are typically spent on rework due to poor quality. This lose of revenue is reflected in the higher cost of goods and services.

Statistical Process Control (SPC): Total quality control involves monitoring processes in order to limit the amount of variation in a product and to improve the process. SPC does not ensure a quality product or process. It only shows that a process is in control, producing products that are expected. When statistical process control is used properly, problem areas can be recognized much sooner. Although there can never be a perfect product, an organization that strives for a process with a little variation as possible will create more quality products.



" Ice Breakers "

TEACHER KEY

We suggest you use these next two pages as ice breakers on the topic of total quality control. It will be very interesting and informative to hear you students' perspectives on the topic. After leading a discussion on their perspectives, proceed to introduce the materials on philosophy, total quality control, teamwork and group problem solving.

NAME:__________________________

DATE:__________________________

WHAT IS QUALITY ?

QUALITY IS ...

QUALITY

COMPARE THE DEFINITIONS

My definition of QUALITY:	The dictionary's definition of QUALITY:	My company's definition of QUALITY:

Discuss:

1. How are these definitions similar? different?

2. When are each of these definitions important?

TEAM ROLES

A team consists of various players. Individuals need to have the opportunity to practice the various roles in order to gain confidence and be effective team members.

Within the classroom structure, an instructor can provide opportunities for team activities. Assign roles and help students understand what their responsibilities are. This practice is invaluable is helping build confidence in order to be open in front of other co-workers.

Possibly one of the most difficult roles for students in our classes is that of recorder. The recorder's spelling ability is exposed to the entire team. It must be made clear from the very beginning that the purpose for the recorder role is not to practice spelling, but to simply capture the ideas of the group. (This might be an opportunity for the instructor to teach some of the key words frequently used in the organization.)

There are several reasons teams often record the meeting notes in front of all the members. When a speaker's ideas are recorded in front of everyone, he/she can immediately check for accuracy. If what was written is not what was meant, changes can be readily made. There are times when individuals feel that an idea they expressed may not have been captured by the recorder. They will repeat the idea again and again, rather than letting it go in order to try to think of even more ideas. When the speaker can see that his/her idea has been captured on paper, he/she will tend to let go and continue to work on producing new ideas. Also, seeing the ideas sometimes sparks other ideas for individuals, ideas on which others can "piggyback" or "hitchhike".

It may be possible to create situations in order to stimulate discussion about problem areas. This would help individuals be prepared "for the real thing". For example, the instructor may 'plant' a bored or unwilling team member during a group activity. Analyze as a group how the facilitator handled the situation. Determine effect ways to respond to bored members.

Another tough situation is the disagreeable member, one who is unwilling to agree to anything the team suggests or one that attacks the facilitator or maybe another individual team member. Allow the students to role play within the classroom setting to gain confidence.

Other situations to be aware of include the timing of meetings. As a class, discuss suggestions to handle a meeting that is taking longer than scheduled or has completed its agenda ahead of time.

Whenever a team activity is undertaken within the context of the classroom, it is valuable to evaluate its effectiveness. This helps bring team member interaction to the conscious level.

TEAM ROLES:

Member:
- Actively participates in each meeting
- Keeps focused on the agenda at hand
- Makes sure his/her ideas are appropriately recorded
- Takes responsibility for his/her action items

Facilitator:
- Helps the team focus on the agenda
- Suggests processes to be used for the meeting
- Offers time limits to move the meeting along
- Recaps the actions and assignments
- Leads the evaluation of the meeting
- Ensures that personal issues are kept out of the meeting

Recorder:
- Writes down the general ideas for all to see
- Uses the words of the speaker, not his/her own
- Does not interpret or analyze the ideas
- Keeps a running account of all action items

TEAMWORK

WIDGET-MAKING

To show the value of teamwork and its affect on quality, an activity centered around creating some imaginary product - a widget - could be effectively used in a classroom setting. This activity could be expanded as much as needed and can address many of the issues related to quality in the workplace.

Decide what your widget is. It should be created with parts that are readily accessible and numerous - Tinker Toys or popsicle sticks, for example. Be sure that it is not too easy to make, yet not too difficult or time-consuming for students who may get frustrated.

Divide the class into groups. Provide them with plenty of 'parts'. You may want to include some 'defective' pieces without acknowledging comments regarding them. Give the groups a limited time (no more than two or three minutes) to create widgets identical to your sample.

Once time is called, count the total number of quality widgets created by each group. Allow the group to discuss strategies or changes they want to incorporate before trying the exercise again. Hopefully, they will now decide to work as a team rather than as a group of individuals. Do not offer input; allow them to decide how to organize the work effort.

Again provide plenty of 'parts' and give them the same allotted time. Now count the number of quality widgets. Did the number increase? Why?

There should be a great deal of discussion following this activity. Were the instructions not clear the first time (often the case in real-life situations)? Did they work as a team the second time vs. as individuals the first go-round? Were they unclear about what your (the customer of the widgets) standards for acceptance were?

Expand on this if the students so desire. Using this as a basis for introducing quality concepts is valuable since it provides students with a hands-on example that you can continually refer to as you become more involved with quality issues.

GROUP PROBLEM-SOLVING

Group problem-solving activities should be a vital component of any adult education class, and especially in a workplace education program. There are several steps to group problem-solving:

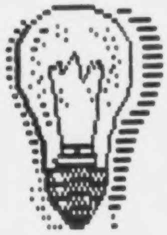
- Get all participants involved.
- Determine what the problem is.
- Brainstorm for possible suggestions for the cause of the problem.
- Organize the brainstorm to try to determine the main cause (a Cause-and-Effect Diagram may be helpful for this step).
- Develop strategies to implement a solution to the problem.
- Test the solution.

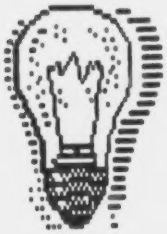
Sometimes what appears to be a problem is actually the result of a problem, not the problem itself. The problem of a car that won't start is probably the result of something inside the car that is not functioning properly. The real problem is not the car itself, it is a part of the car. In order to determine the real problem, it is helpful to ask "Why" about each suggested problem. For example, "Why won't the car start?" "The generator light is not coming on." "Why?" "Possibly there is no juice coming from the battery." "Why?" Continue this process until the group runs out of suggestions.

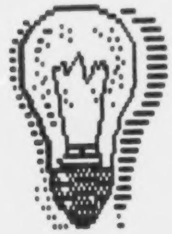
The dead car situation above could be used as an introductory activity to group problem-solving. Because this is often a real-life situation, all students should be active participants and willing to share ideas. After brainstorming for all the possible causes for the problem, the list should be organized. A cause-and-effect diagram would help in this organization since it graphically shows the relationship of the possible causes. Have the students then decide what would be a logical plan for determining exactly what the problem is. How could a possible solution be tested?

A few more problem-solving activities follow. We encourage you to ask your students to bring their own work-related problems to class. Not only would this provide more opportunities for practicing problem-solving techniques, any organizational problems that could be solved would definitely impress management!

Brainstorming







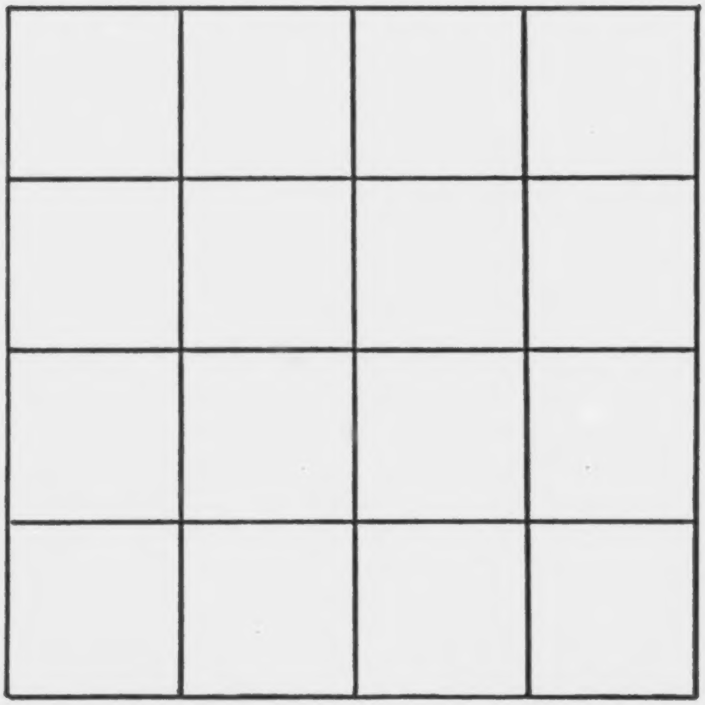
1. No criticizing
2. All ideas are acceptable
3. The more ideas the better
4. Hitchhike
5. All participate

PROBLEM-SOLVING

COUNTING SQUARES

Another problem-solving activity involves the simple activity of counting squares in the drawing below. Students are encouraged to quickly count the total number of squares and jot the amount on a sheet of paper. When all the students have completed the task, compare answers. Answers will probably vary. (The correct answer, by the way, is 30: 1 whole square, 9 squares consisting of 4 units, 4 squares of 9 units, and 16 small individual units.)

The objective of this activity is to show students that people look at problems and situations from varying perspectives. No two people think or tackle a problem the same way. It is valuable, in looking at a problem, to not just look at the whole or the individual components, but also to look at how the individual components relate to one another.



PROBLEM-SOLVING
ACTIVITY

As a class, present a problem. Offer a problem in which the students can test their ideas. An example problem is this: "How long can you keep a ping pong ball in motion?"

The students could then brainstorm about possible solutions. Further questions ought to arise: Are there limits to the materials that can be used? How long do we have to solve the problem? Be prepared to provide guidance for them so that there are acceptable limits to the solutions of the problem.

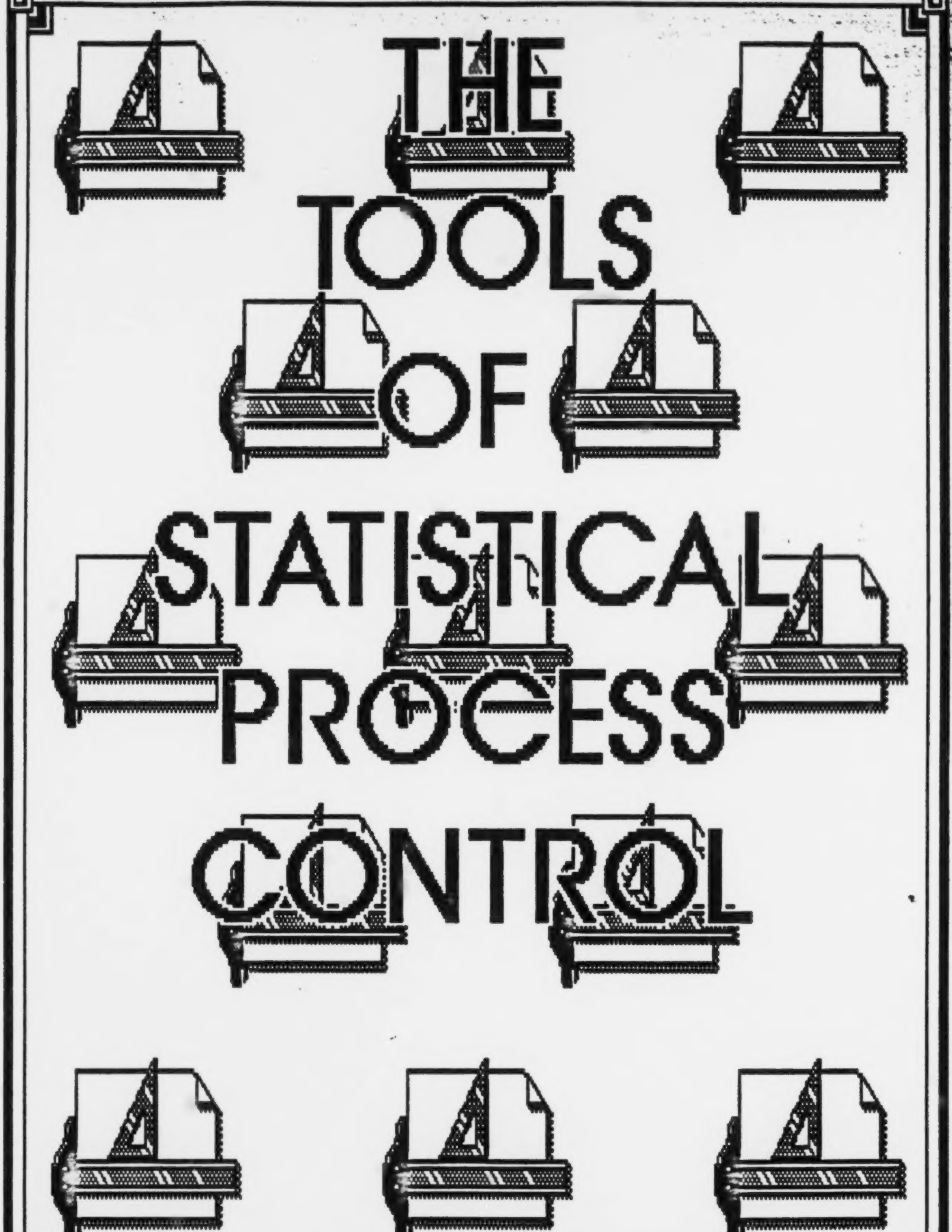
For the example above, you may have some materials available in the classroom or suggest students bring in materials to be used to test solutions. Allow the students to test out their ideas before judging the suggestion as good or bad. As a group, students should be able to determine what an acceptable solution is. Consensus may be needed here.

FOLLOWING DIRECTIONS
ACTIVITY

As a class, give instructions on how to perform a task. A suggestion is to use a paper cutting activity. After students have completed the task, discuss why some people completed the task correctly while others did not (if there were those unable to follow directions correctly). Probably those students who did complete the task asked each other for help.

Teamwork involves helping each other when directions are given, when there is a task to be completed. Students should be encouraged to help each other by offering suggestions and guidance when it is needed.

Stress the difference between performing a task for another individual and offering guidance so an individual on his/her own can be successful.



THE TOOLS OF STATISTICAL PROCESS CONTROL

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DATA

Data is collected to make decisions - to separate fact from fiction. Everyone collects data to make decisions. Most people look at data on their finances before they purchase a new home or car. With today's economy, few people shop without comparing various prices for bargains. At work it is important to know how to collect data on a process being operated as well as what type of data to collect. There are three types of data that can be collected:

1. **Variable data** (also known as **measurable** or **continuous** data) - data that can be measured on a continuous scale. For example: measuring the height or weight of a product. Also scores on tests with a range from 0 -100.

2. **Attribute data** (also known as **countable** or **discrete** data) - data that must be counted; it can't be measured on a continuous scale. For example: counting the number of defects in a part. Educators would use attribute data in counting the number of errors a student makes on a test.

3. **Subjective data** - data rated on how a person feels about something. For example: the scoring by Olympic judges on figure skating or diving. The scores from an essay test could be considered subjective data.

To show the difference in the three types of data, let's look at this example. If you were asked to count the number of students who are a particular age, you are collecting attribute data. If, instead, you decide to collect data on each student's age, you now have variable data since ages fall into a continuous scale. Let's say now that you are asked to organize students into age groups (i.e., 25 - 30, 31-35, 36 -40) according to the age you THINK they are. This would definitely involve making some subjective decisions.

The most reliable type of data is variable data. Attribute data is the second most reliable. It is not wise to make many decisions based on subjective data simply because of its relative nature.

Data needs to be collected in a clear and an easily understood manner. Check sheets are excellent tools for collecting data because they provide a means for organizing and tallying data in a consistent manner.

There can't be an operator on second shift making a measurement while a part is still hot and a third-shift operator measuring a part after it has cooled for two hours. Data must also be collected following the same procedure and with the same measuring device.

NAME:____________________

DATE:____________________

Identifying Types of Data

STUDENT WORK SHEET

Practice identifying types of data. For each, check whether it is variable (V), attribute (A), or subjective (S) data.

	V	A	S
1. Number of cars traveling a road daily			
2. Air pressure			
3. Opinion surveys			
4. Bad parts in a box			
5. Weight of a product			
6. Days absent from work			
7. Score for Olympic figure skating			
8. Temperature of a part			
9. Number of people taller than 5 feet			
10. A "10" for Bo Derek			

Identifying Types of Data

TEACHER KEY

Practice identifying types of data. For each, check whether it is variable (V), attribute (A), or subjective (S) data.

	V	A	S
1. Number of cars traveling a road daily		x	
2. Air pressure	x		
3. Opinion surveys			x
4. Bad parts in a box		x	
5. Weight of a product	x		
6. Days absent from work		x	
7. Score for Olympic figure skating			x
8. Temperature of a part	x		
9. Number of people taller than 5 feet		x	
10. A "10" for Bo Derek			x

SAMPLING

For years, most companies have relied on 100% inspection to ensure that the products they produce meet their customers specifications. However, this method is not only inaccurate but is costly as well. No person, no matter how well trained he is will be able to detect all defective products 100% of the time. To help prove this point to yourself as well as to your students conduct one or more of the activities provided on the following pages.

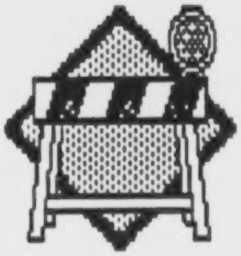
An alternative to 100% inspection is sampling. Sampling is based on the belief that a random part is an accurate representation of the whole. In technical terms, a random sample is an accurate representation of the total population (the total amount of products produced from a process).

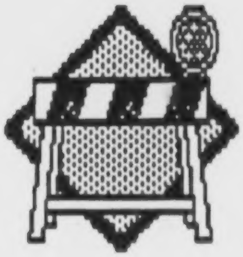
There are two types of sampling: grab and composite. A grab sampling is one handful of products "grabbed" from a process. Whereas, a composite sample is a series of grab samples put together. Which ever type of sampling a company uses, the purposes of sampling is to cut down on inspection time by simply inspecting a representation of the total population and to increase the efficiency of defect detection. Also, from the data gathered by sampling, a company can discover the patterns of variation that normally exist and can, with the use of statistical tools, take steps to reduce that variation.

Things to remember about sampling:

1. Sampling must be random
2. Sampling procedures must be consistent. That is products must be sampled at times consistent over all working shifts and at consistent stages of production.
3. Sampling measuring system must be as uniform as possible.
4. Sampling must be done often in order to get a true picture of the current process.

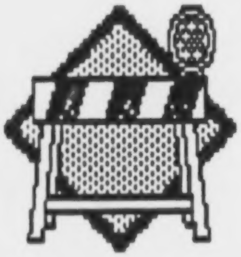
It would be beneficial for you as a teacher to investigate the sampling techniques used in your company. Ask your students which type of sampling they have used in the past. Lead a discussion on the accuracy of sampling versus 100% inspection.

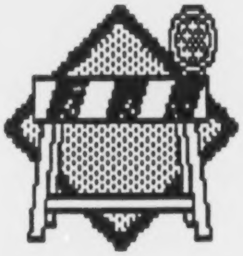




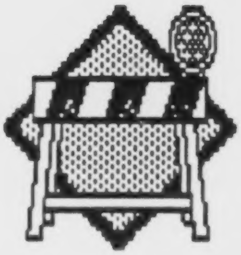
SAMPLING ACTIVITY #1 "THE F TEST"

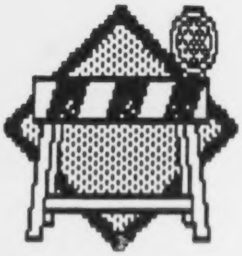
To conduct The F Test write the sentence on the following page on a transparency or simply give each student a copy of the page itself. Then instruct your students to read through the sentence only once (100% inspection, not 200%) counting all the Fs they can find. Then ask each student how many Fs they counted. Record each answer on a chalk board or flip chart. Explain how this exercise demonstrates the inaccurracy and time costlyness of 100% inspection. By the way, there are 6 Fs in the sentence.





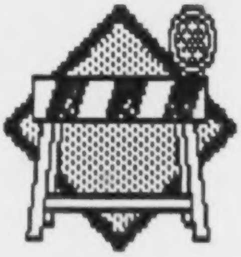
If I had the
time, I would
tell my story
of how I
effortlessly
jumped into
a sea of foam.

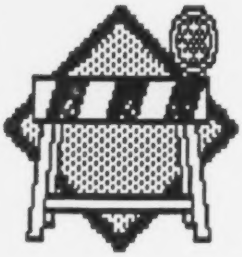




SAMPLING ACTIVITY #2 "FAULTY QUIPS"

The following three pages contain Faulty Quips which you can use to once again demonstrate the inaccuracy of 100% inspection. The best way to use these is to copy them onto a transparency or rewrite them onto a larger page. Instruct your students to read each one only once as you hold them up. After you've shown all three ask your students if they found any errors or defects in the sentences. Go around asking each student. Only the most alert inspector (and sometimes not even "the most alert") would have detected the repetition of the words: the, last and try.





Too many
cooks
spoil the
the broth!

He who
laughs last
last, laughs
best.

If at first you
you don't
succeed, try
try again !

CHECK SHEETS

Check sheets are used when you need to gather data based on sample observations in order to begin to detect patterns. This is the logical point to start in most problem solving cycles.

Check sheets are simply an easy to understand form used to answer the question, "How often are certain events happening?" It starts the process of translating "options" into "facts". Constructing a check sheet involves the following steps:

1. Agree as to exactly what is being observed. Each data collector has to be looking for the same thing.

2. Decide on the time period during which data will be collected. This could range from hours to weeks.

3. Design a form that is clear and easy to use making sure that all columns are clearly labeled and that there is enough space to enter the data.

4. Collect the data consistently and honestly. Make sure there is time allowed for this data gathering task.

HELPFUL HINTS:

* Make sure that observation samples are as random as possible.
* Make sure the sampling process is efficient so that people have time to do it.
* Populations being sampled must be homogeneous. If not, it must first be grouped with each grouping sampled individually.

Types of check sheets:

1. Tally sheet
   i.e. reasons for disagreements with spouse

2. Concentration chart
   i.e. floor plan of plant - placing X's where find safety hazards

3. Defective item check sheet
   i.e. list all possible defects, inspect samples for those defects

4. Contents check list
   i.e. a type of inventory list to insure all components are present

CHECK SHEETS

With a partner, create a check sheet you can use on your job to collect data. You will use the data you've collected to help make decisions about a process you perform. Keep your check sheets simple and practical.

TALLY SHEETS

Tally sheets are the simplest types of check sheets you can use to quickly and efficiently collect and tabulate data. Tally sheets simply keep an easy-to read record of the information you want to track. An everyday example is using a tally sheet to keep record of how many rounds a person wins in a card game. In industry, tally sheets can be used to track how many times a machine breaks down, how many defects appear in a product or how many sales were made on a certain day. In education, a teacher can use a tally sheet to record how many of a particular error her students make when writing a paragraph. An example of this is shown below:

ERRORS	PARAGRAPHS	TOTALS
1 CAPITALIZATION		
2 SPELLING		
3 PUNCTUATION		
4 VERB FORM		
5 PREPOSITIONS		

Tally sheets are very easy to construct. As in the example above, simply list the types of errors you want to keep track of. Then read through your students paragraphs. Every time you come across one of the errors in the check sheet put a tally mark (1) in the corresponding row. For ease in tabulation, group every five tallies like this: 1111. After reviewing all your students paragraphs, you can easily calculate the total number of errors for each kind. This will enable you as a teacher to see clearly the types of writing mistakes your students are making.

To facilitate your understanding of how tally sheets can be used, A similar example of paragraph errors is included. You can use this example as a class activity or come up with your own examples. It would be best to have your students come up with examples of how they could use tally sheets on their jobs or in their classes.

NAME:________________

DATE:________________

Paragraph Pitfalls
Tally Sheet

STUDENT WORK SHEET

Directions: Read through each of following paragraphs. Record the "pitfalls" (errors) in the tally sheet on the next page.

P#1 Everyday, carol[1] works the same scedule.[2] She goes to work on[5] 7:00 in the morning Then she goes to school at her workplace from 11:30 to 12:30. from[1] 2:20 to 2:30 she takes a break. After her break, she goes back to work until 3:30. then[1] she leaves works[2] to go home.

P#2 Everyday, Ny works the same schedule. She leave[4] her house at 6:30 in the morning and arrive[4] at work at 650[3] She begin[4] to work at 7:00 AM and continue[4] until 10:00 when she take[4] a ten minite[2] break. At[5] 11:30 to 12:30 Ny go[4] to school. then[1] at 12:30 she returns to work. At 2:20[3] she take[4] another ten minite[2] break. After that she work[4] for an hour and then go[4] home at 3:30.

Paragraph Pitfalls
Tally Sheet

P#3 Sandy goes to $\overset{2}{\text{works}}$ at 6:30. $\overset{1}{\text{at}}$ 7:00 she $\overset{4}{\text{start}}$ to $\overset{2}{\text{works}}$ and $\overset{4}{\text{continue}}$ $\overset{2}{\text{untill}}$ 10:00. $\overset{1}{\text{after}}$ 10:00 she takes her $\overset{1}{\text{Break}}$ $\overset{2}{\text{untill}}$ 10:10. $\overset{1}{\text{from}}$ 11:30 to 12:30 she $\overset{4}{\text{study}}$ $\overset{1}{\text{english}}$ in class$\overset{3}{\text{.}}$ $\overset{1}{\text{after}}$ class she goes $\overset{1}{\text{Back}}$ to $\overset{2}{\text{works}}$ until 3:28. $\overset{1}{\text{at}}$ 3:30 she goes home.

P#4 Everyday, Steve works at $\overset{1}{\text{fay}}$ $\overset{1}{\text{corporation}}$ He starts to work $\overset{5}{\text{on}}$ 7:00 AM and he goes to class at 11:30 AM. $\overset{1}{\text{then}}$ $\overset{1}{\text{He}}$ goes back to work at $\overset{3}{\text{12:30}}$ He takes a break at 2:30 to 2:40 and $\overset{1}{\text{He}}$ leaves work 3:30 PM.

PITFALLS	PARAGRAPHS	TOTALS
1 CAPITALIZATION		
2 SPELLING		
3 PUNCTUATION		
4 VERB FORM		
5 PREPOSITIONS		

Paragraph Pitfalls
Tally Sheet

TEACHER KEY

P#1 Everyday, carol[1] works the same scedule.[2] She goes to work on[5] 7:00 in the morning Then she goes to school at her workplace from 11:30 to 12:30. from[1] 2:20 to 2:30 she takes a break. After her break, she goes back to work until 3:30. then[1] she leaves works[2] to go home.

P#2 Everyday, Ny works the same schedule. She leave[4] her house at 6:30 in the morning and arrive[4] at work at 650[3] She begin[4] to work at 7:00 AM and continue[4] until 10:00 when she take[4] a ten minite[2] break. At[5] 11:30 to 12:30 Ny go[4] to school. then[1] at 12:30 she returns to work. At 2;20[3] she take[4] another ten minite[2] break. After that she work[4] for an hour and then go[4] home at 3:30.

P#3 Sandy goes to works[2] at 6:30. at[1] 7:00 she start[4] to works[2] and continue[4] untill[2] 10:00. after[1] 10:00 she takes her Break[1] untill[2] 10:10. from[1] 11:30 to 12:30 she study[4] english[1] in class .[3] after[1] class she goes Back[1] to works[2] until 3:28. at[1] 3:30 she goes home.

P#4 Everyday, Steve works at $\overset{1}{\text{fay}}$ $\overset{1}{\text{corporation}}$. He starts to work $\overset{5}{\text{on}}$ 7:00 AM and he goes to class at 11:30 AM. $\overset{1}{\text{then}}$ $\overset{1}{\text{He}}$ goes back to work at 12:30$\overset{3}{.}$ He takes a break at 2:30 to 2:40 and $\overset{1}{\text{He}}$ leaves work 3:30 PM.

PITFALLS	PARAGRAPHS	TOTALS
1 CAPITALIZATION	卌 卌 卌 ||	17
2 SPELLING	卌 ||||	9
3 PUNCTUATION	||||	4
4 VERB FORM	卌 卌 ||	12
5 PREPOSITIONS	|||	3

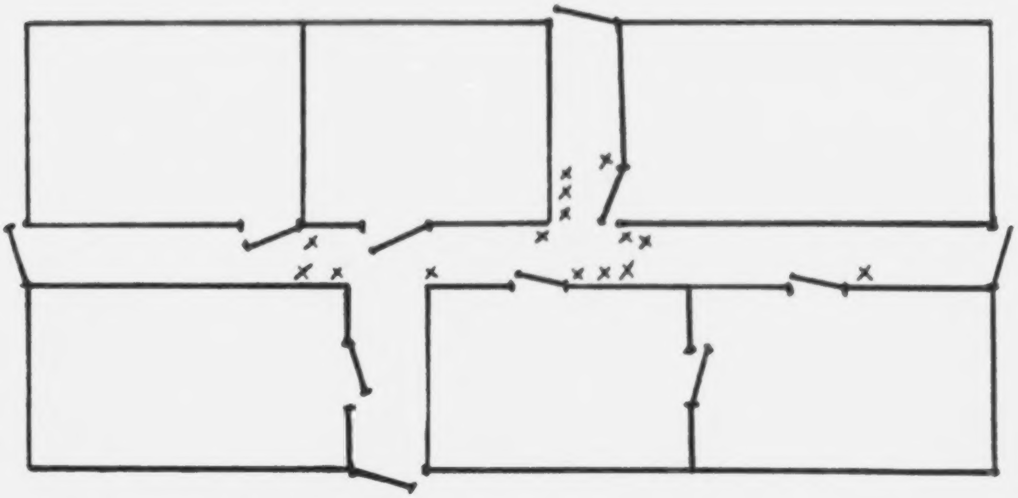
CONCENTRATION CHARTS

A concentration chart or diagram is a type of check sheet used to collect data on specific areas. A simple drawing of the item being monitored can be made. Then data can be collected directly onto the chart corresponding to the item itself. For example, a company may want to monitor the placement of chips or dents on an item of furniture. A concentration chart drawn of that item can be used to document the exact location of the defects. Later, this data can be used to discover where the most frequent defects occur so that action can be taken.

The following activity is an example of a concentration chart on safety hazards. The area to be monitored is duplicated onto a workable model. This specific concentration chart used X's to show where accidents had occurred on the job.

As a class activity, ask the students to decide where the heaviest concentration of accidents appears to be occurring.

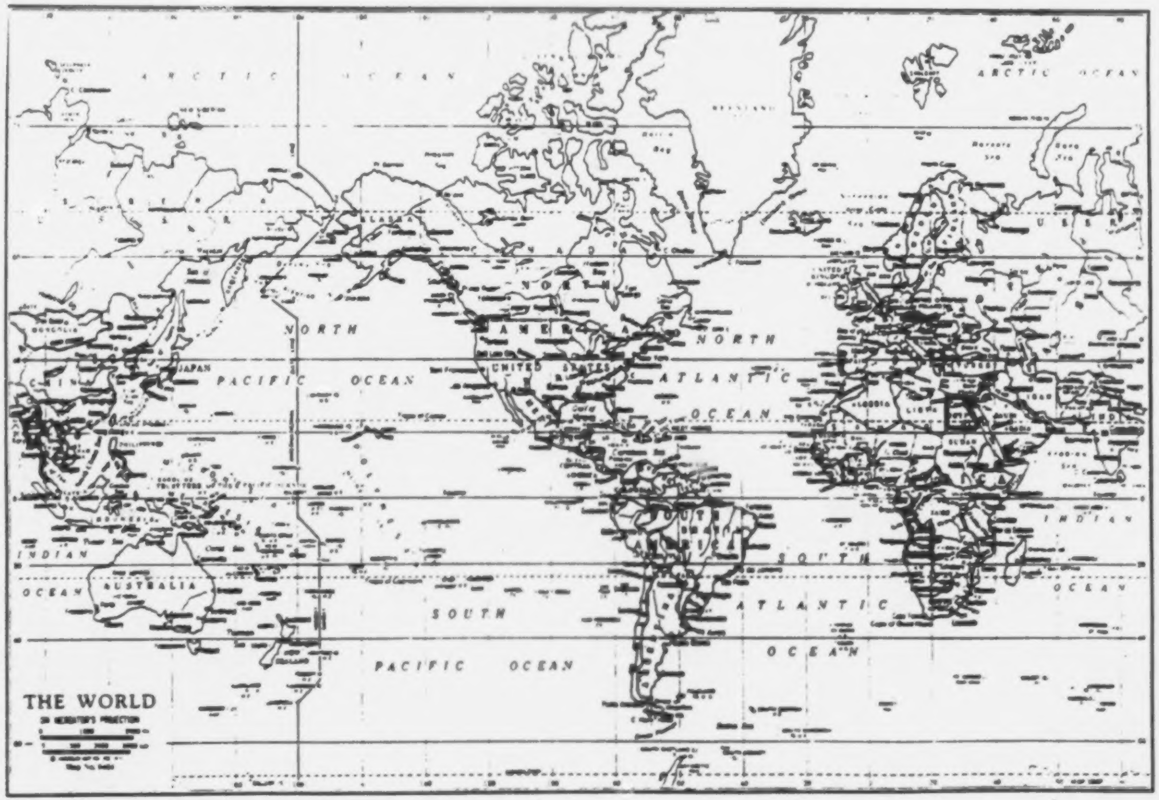
It is important to remember that data collected on any type of checksheet does not provide reasons or solutions to any problems. It only offers documentation so that a problem/situation can be further examined. An excellent extension to this activity would be for students to suggest reasons why heavy concentrations of accidents occur in particular areas.



x = accident site

CONCENTRATION CHARTS
PLOTTING ON A MAP

Below is a copy of the map of the world. A way to clarify for students this tool is to use the world map to do a class activity. Have each student place a colored dot on his homeland. Then discuss where the greatest concentration of people (from the class) tend to come from. What does this suggest? This exercise offers many possibilities for extension into conversations and writing activities about diversity. (If all your students come from a particular country, it may be more feasible to use a map of that country only.) An extension of this could be to use a city map to find out where most of the students live. Is there a larger concentration of students living in one area vs. another? Not finding a clear concentration of items is just as revealing as discovering that there are heavy concentrations in particular areas. As a class, discuss why this is so.


ARCTIC OCEAN
ARCTIC OCEAN
U.S.S.R.
U.S.S.R.
CHINA
JAPAN
NORTH PACIFIC OCEAN
NORTH AMERICA
UNITED STATES
NORTH ATLANTIC OCEAN
SOUTH AMERICA
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
INDIAN OCEAN
AUSTRALIA
SOUTH PACIFIC OCEAN
THE WORLD

ARCTIC OCEAN
ARCTIC OCEAN
GREENLAND
U. S. S. R.
CANADA
NORTH AMERICA
UNITED STATES
JAPAN
CHINA
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH AMERICA
SOUTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
INDIAN OCEAN
INDIAN OCEAN
AUSTRALIA
THE WORLD
ON MERCATOR'S PROJECTION

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INVENTORY CHECK SHEETS

Inventory check sheets are exactly what they say. They are check sheets that are used to take an inventory of something. An inventory check sheet could be used by a teacher to make sure her student's sentences contain the three essential parts of a sentence: subject, verb and completor. The check sheet might look like this:

	S#1	S#2	S#3
subject			
verb			
completer			

As the teacher reviews each sentence, she would put a tally mark for each subject, verb, completer she finds. In this way, the teacher can easily see which sentences do and which sentences do not contain the three essential parts.

Inventory check sheets are also used in industry. An operator may be required to use one as a final inspection procedure to make sure all the parts of a product are present or if all the items in an order are being sent.

SUGGESTED ACTIVITIES:

Have students brainstorm situations for which they could use an inventory checksheet on their jobs. Have them construct it and put it into practice. Discuss how it could be used for other procedures in their company.

PARETO CHARTS

The Pareto chart was the creation of Wilfredo Pareto, an Italian social scientist. He observed that 80% of the wealth was owned by 20% of the people. He further observed that 80% of the problems come from 20% of the machines or people. The Pareto Principle or the "80-20" Rule states simply that 80% of problems generally come from 20% of the machines, raw materials, or manpower. The 20% of the causes are called the "vital few"; 80% of the causes are called the "useful many".

A Pareto chart is a bar chart in which the classes or groups are arranged in descending order according to their frequency or order of importance (in the case of cost). A Pareto chart can help to identify the highest priority issues or problems. Once a Pareto chart signals a key problem or error, that key problem should be further analyzed and tested to be sure that the chart is accurately portraying the data.

Once a problem has been identified and corrected, another Pareto chart should be created for comparison to the original. This "post-Pareto" also serves as a pre-Pareto chart. An organization uses it not only to show the results of improvement efforts, but also to look at which issue or problem is occurring most frequently since changes have occurred.

Pareto charts are frequently used in business since they provide the first step in solving problems or making improvements in processes. If there are disagreements as to what issue is creating the greatest problem, a Pareto chart can quickly show a team what the most frequently occurring problems is.

Advanced Pareto charts are drawn with cum (cumulative) lines along the right hand axis. The cum line simply tell us what the percentage of the overall problem each item is. Using the right hand cum line and the left-hand frequency labels allows us to determine the number of problems occurring as well as the percent of the total that each represents.

Following are sample Pareto charts. Students should be able to determine what problem areas should be focused on first. They should be able to read, interpret, and create their own Pareto charts. For initial introduction to Paretos, we have left off all cum lines. If students are required to interpret Paretos using cum lines at work, we recommend that you ask a company representative to give you and your class a presentation on cum lines and Pareto charts.

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PARETO CHART ACTIVITY

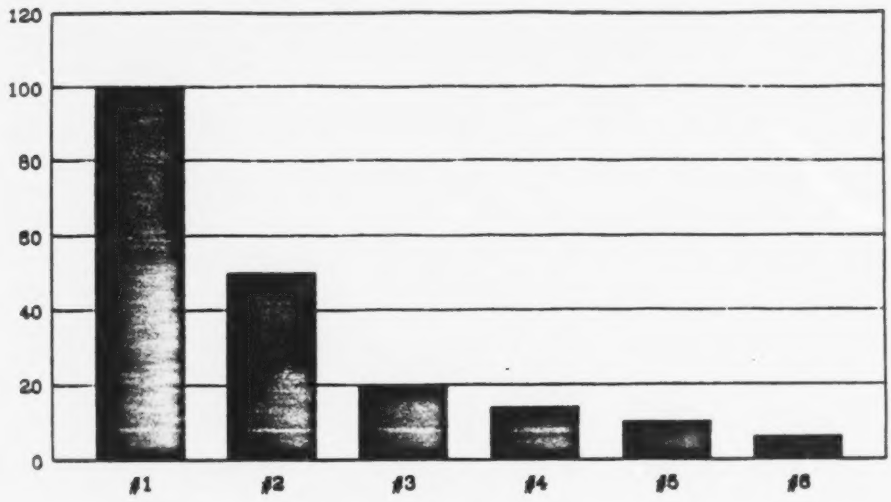
The "Paragraph Pitfalls" tally sheet from page 35 can be used as an initial activity on Pareto charts. The "pitfalls" are considered the problem areas.

As a class, decide what areas of instruction the teacher should be addressing first.

This activity could be adapted by the instructor to become a meaningful exercise. Use real data from students' work to create a pre-Pareto chart. Don't forget to create a post-Pareto to show students how they are progressing and how well you are teaching!

Big Bill's Building Barn

Errors in Billing



Total errors: 200

#1: Payment not credited in time

#2: Undercharged account

#3: Double-charged account

#4: Incorrect address

#5: Invoices lost

#6: Wrong account number

Big Bill's Building Barn

Errors in Billing

1. Find the percent of the total number for each error (Hint: Find the fractional part first. Then use mental math to figure the percentages.)

#1: ____________________

#2: ____________________

#3: ____________________

2. Find the fractional part of the following errors. Then calculate the percent of error.

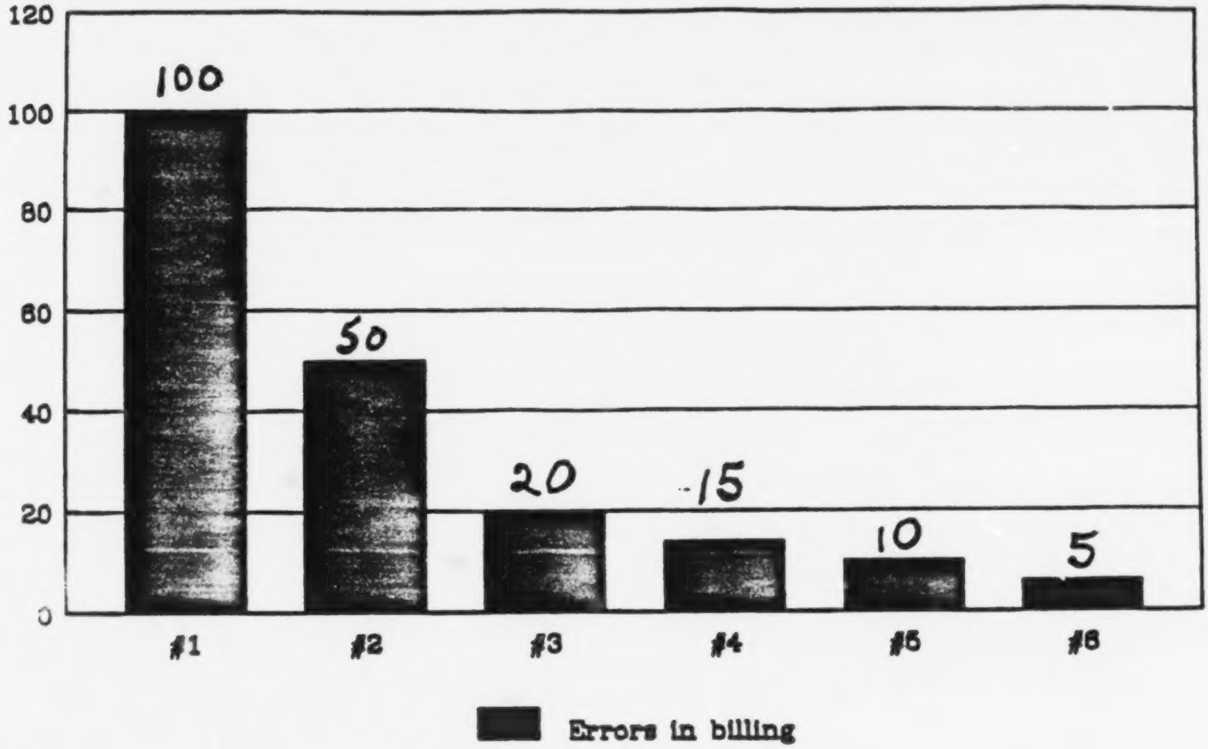
	Fraction	Percent
#4:	____________	____________
#5:	____________	____________
#6:	____________	____________

3. Why do you think there are so many payments that are not credited in time?

4. What would you offer as a suggestion to correct the problem?

Big Bill's Building Barn

Errors in Billing



Total errors: 200

#1: Payment not credited in time

#2: Undercharged account

#3: Double-charged account

#4: Incorrect address

#5: Invoices lost

#6: Wrong account number

Big Bill's Building Barn

Errors in Billing

Comment: If students have difficulty with this exercise, they made need to be reminded of what a fraction is and how it relates to a percent. They should be able to use mental math to solve some of these problems. See Qualitative Math section for suggested teaching strategies.

1. Find the percent of the total number for each error (Hint: Find the fractional part first. Then use mental math to figure the percentages.)

#1: 100/200 = 1/2 = 50%

#2: 50/200 = 1/4 = 25%

#3: 20/200 = 1/10 = 10%

2. Find the fractional part of the following errors. Then calculate the percent of error.

	Fraction	Percent
#4:	15/200 = 3/40	7.5%
#5:	10/200 = 1/20	5%
#6:	*5/200 = 1/40	2.5%

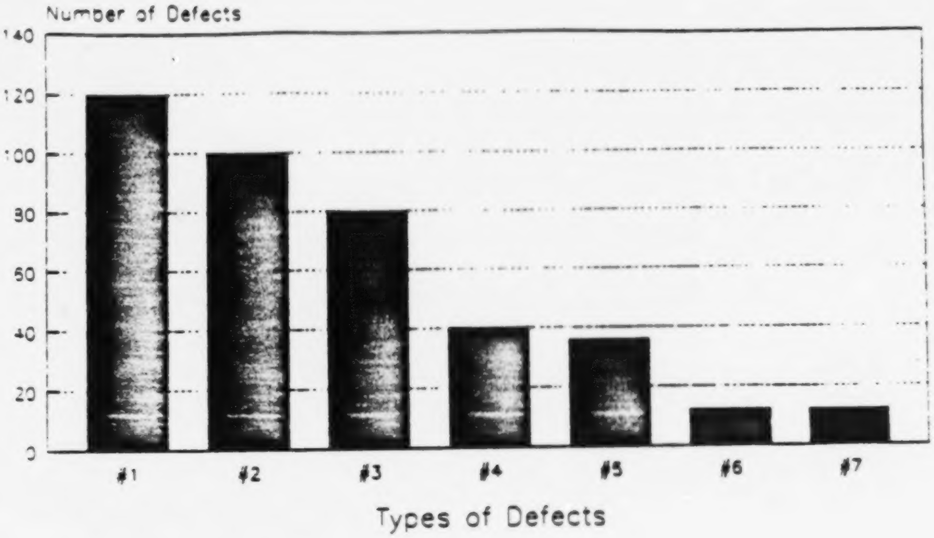
*5/200 is half of 10/200 ∴ 1/2 of 5% is 2.5%

3. Why do you think there are so many payments that are not credited in time?

4. What would you offer as a suggestion to correct the problem?

Quality Trousers Trade

Defects in Workmanship



Total defects: 400

#1: Inseam not double-stitched

#2: Uneven legs

#3: Zipper crooked

#4: Back pocket sewn shut

#5: Snags in cloth

#6: Seat of pants too baggy

#7: Hole in pocket

Quality Trousers Trade

Defects in Workmanship

1. Defect #1 represents what type of defect?

2. Defect #5 represents what type of defect?

3. Defect #1 represents what percent of the total number of defects?

4. Defect #2 represents what percent of the total number of defects?

5. Crooked zippers represents what percent of the total number of defects?

6. The first three defects equal what percent of the total defects?

7. How many times were back pockets sewn together?

   This represents what percent of the total number of defects?

8. Defect #5 and #6 consist of about how many defects each?

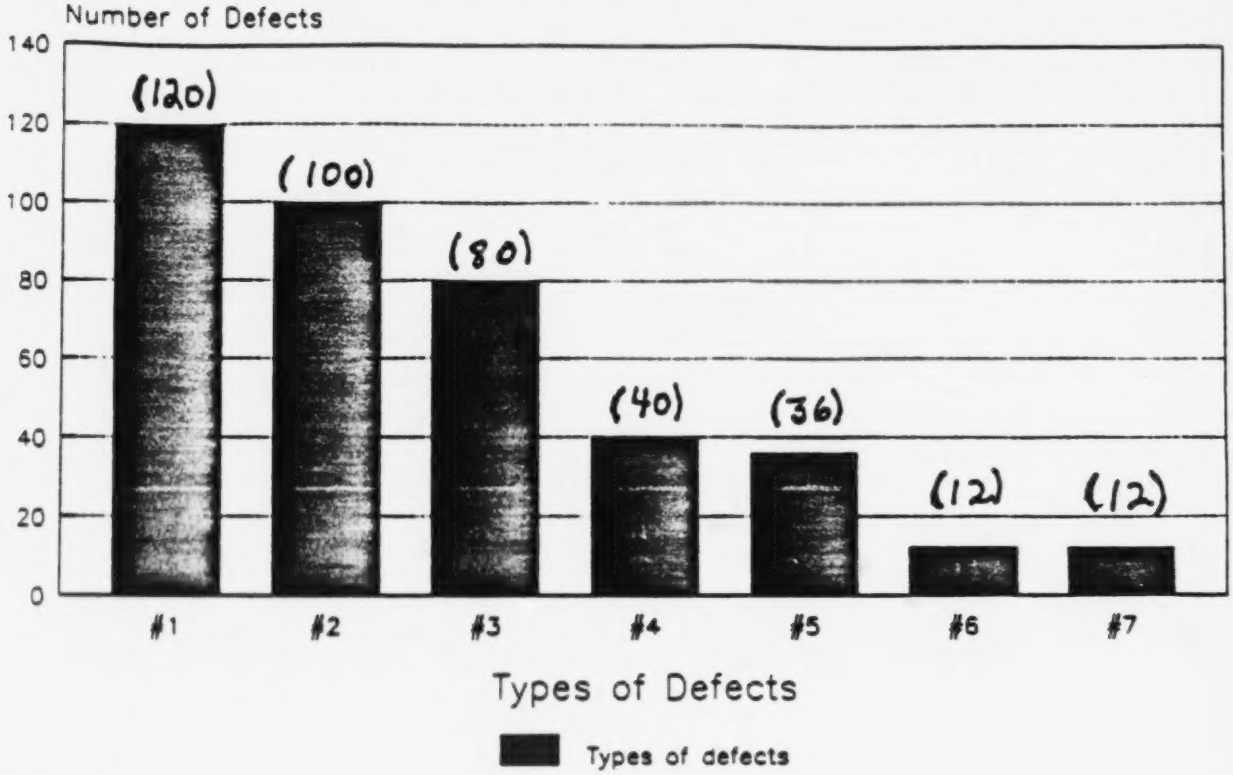
   Each defect represents about what percent of the total?

9. As a team looks at this Pareto chart, what do you think will be some of its recommendations?

10. What do you think could be some of the causes for so many inseams not being double-stitched?

Quality Trousers Trade

Defects in Workmanship



Total defects: 400

#1: Inseam not double-stitched

#2: Uneven legs

#3: Zipper crooked

#4: Back pocket sewn shut

#5: Snags in cloth

#6: Seat of pants too baggy

#7: Hole in pocket

Quality Trousers Trade

Defects in Workmanship

COMMENTS: All calculations for this activity should be done without the aid of a calculator. If students have no number sense for changing fractions to percents, we encourage you to provide them with experience in developing mental math number sense skills. See the math section for more information and suggested activities.

1. Defect #1 represents what type of defect?

   "Inseams not double-stitched"

2. Defect #5 represents what type of defect?

   "Snags in cloth"

3. Defect #1 represents what percent of the total number of defects?

   $$\frac{120}{400} = \frac{12}{40} \div \frac{4}{4} = \frac{3}{10} = 30\%$$

4. Defect #2 represents what percent of the total number of defects?

   $$\frac{100}{400} = \frac{1}{4} = 25\%$$

5. Crooked zippers represents what percent of the total number of defects?

   $$\frac{80}{400} = \frac{8}{40} = \frac{1}{5} \times \frac{2}{2} = \frac{2}{10} = 20\%$$

6. The first three defects equal what percent of the total defects?

   $$30\% + 25\% + 20\% = 75\%$$

Quality Trousers Trade

Defects in Workmanship

7. How many times were back pockets sewn together?

   40

   This represents what percent of the total number of defects?

8. Defect #5 and #6 consist of about how many defects each?

   12 of each type of defect

COMMENT: If students have difficulty deriving a fairly close estimate for this question, they may need more practice in estimating calibrations. See the math section for more information and sample activities.

Each defect represents about what percent of the total?

$$\frac{12}{400} = \frac{3}{100} = 3\%$$

9. As a team looks at this Pareto chart, what do you think will be some of its recommendations?

COMMENT: This should be a group problem-solving activity.

10. What do you think could be some of the causes for so many inseams not being double-stitched?

COMMENT: This should be a group problem-solving activity.

School Drop-outs

Most common causes

Create a Pareto chart using the information below. Then compute the percentage of each.

REASONS	NUMBER OF RESPONSES
• Health problems	36
• Bored with school	450
• Drug-related problems	63
• Family problems	216
• Had to go to work	135

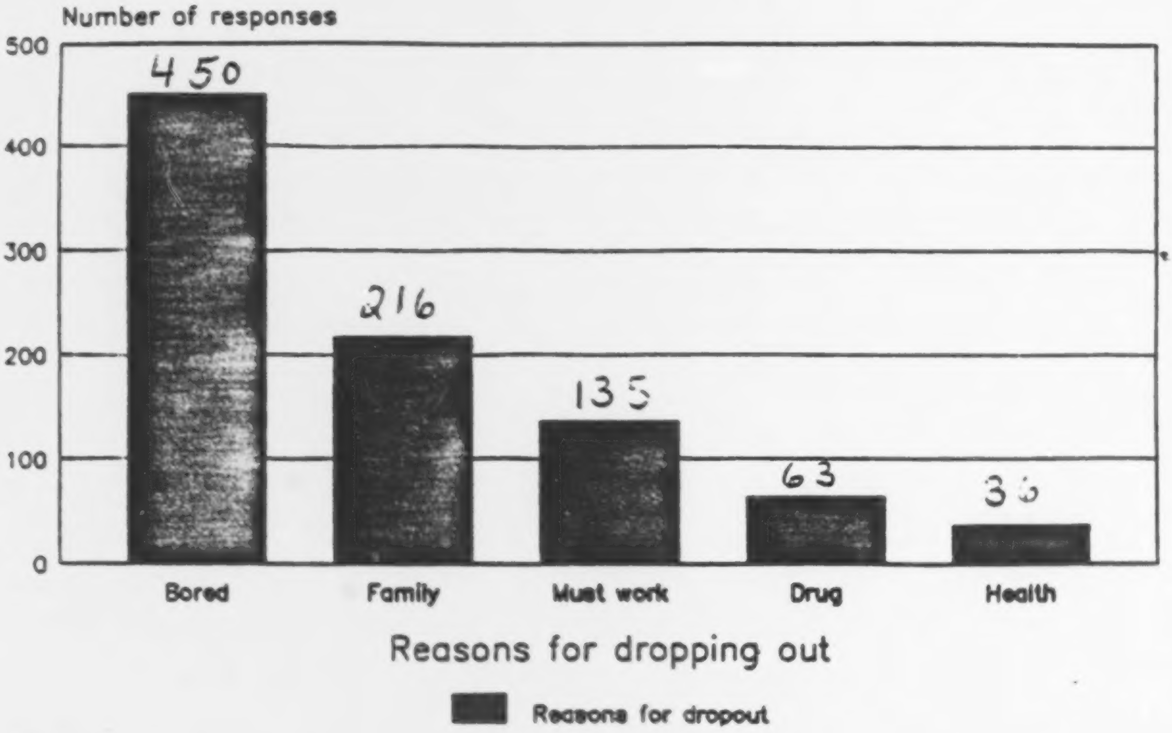
School Drop-outs

Most common causes

Create a Pareto chart using the information below. Then compute the percentage of each.

REASONS	NUMBER OF RESPONSES
. Health problems	36
. Bored with school	450
. Drug-related problems	63
. Family problems	216
. Had to go to work	135

Comment: Help students choose intervals that are easily read, i.e., intervals of 100. This Pareto chart will give students an opportunity to practice estimating calibrations (See appendix for further examples).



Total number questioned: 900

CENTRAL TENDENCIES

Sometimes it is helpful to represent a set of data in terms of a single number to describe the entire set. What number is chosen depends on the characteristic to be described. Most often, we want to describe the center, or middle, of a set of data. This is referred to as a MEASURE OF CENTRAL TENDENCY (also referred to as AVERAGE). It is the location of the center of the set of data, or distribution. There are three commonly used measures of central tendency: the MEAN, the MEDIAN, and the MODE. In a normal distribution (a 'normal curve'), the mode, median, and mean are the same.

Most of us are already familiar with finding the MEAN, or 'arithmetic mean', of a group of data. (We generally call it the "average" although median and mode are also considered averages.) The formula for finding the MEAN looks like this:

$$\bar{X} = \frac{\Sigma x}{n}$$

where $\bar{X}$ (read X-bar) represents the MEAN and Σ is the symbol for 'summation'. X refers to the individual values within a set of data and n is the number of total values.

Although the formula looks unfamiliar to many of us, it simply means to find the sum of all the values in a set of data divided by the total number of values.

To find the MEAN for the set of data: 5, 4, 3, 6, and 7, for example, we add the values (for a total of 25). We then divide by the number of values or items (in this case there were 5 items in the set) to get a MEAN of 5.

Other useful information can be found by arranging data in order from the smallest to the largest. The MEDIAN is the middle value in the arranged data. Exactly half of the values fall above and below the MEDIAN. If there is an even number of items, the MEDIAN is the average of the two middle numbers.

The MEDIAN for the set of data used in the previous example can be readily found after the data is rearranged is ascending order. 3, 4, 5, 6, 7. The middle number, or MEDIAN, for this set of data is 5.

The MODE is the value that occurs most frequently in a set of data. In the set of data used above, there is no MODE since one item in the set does not occur any more frequently than another. To find the MODE in this set of data: 3, 4, 7, 3, 6, 1, 4, 7, 3, simply look for the item that occurs most often. In this example, the MODE is 3 because there are more 3's than another values.

There are times when one MEASURE OF CENTRAL TENDENCY is preferred over another.

- If the values in a set of data are not in order, it is sometimes easier to compute the MEAN.
- If the values in a set of data are arranged in order by size or in a frequency table, the MEDIAN can be quickly found by a simple visual inspection.
- If it is not desirable to measure every item in a sample, the MEDIAN can still be readily found. For example, if you wanted to know something about the heights of a group of people, all that would need to be done is line the people up by heights. The middle person could then be visually found and his height measured to determine the MEDIAN of the group.
- By using one measure of central tendency over another, data can sometimes be interpreted in a biased manner.

The example below illustrates how the measures of central tendency can be presented to show biases.

Salaries of employees at B. Smart Thrift Company:

Boss:	$100,000
Older son:	$ 55,000
Younger son:	$ 50,000
2 Admin. Asst. each at:	$ 10,000
5 Workers each at:	$ 5,000

Mr. B and the union representative are having some heated discussions about the salaries of the workers. Mr. B says that the average employee salary at B. Smart Thrift Company is $25,000 which is above the national average!

Do you know what measure of central tendency Mr. B is using?

The MEAN:

	100,000	
	55,000	
	50,000	
	20,000	**(10,000 X 2)**
	25,000	**(5,000 X 5)**
	250,000	

250,000 ÷ 10 (total number of employees) = $25,000

The union representative argues with Mr. B. She says that the average employee salary is $5,000.

Do you know what measure of central tendency the union representative is using?

The MODE: The most frequent salary is $5,000.

Because of the heated discussions, Mr. Arby Traitor comes in to settle the dispute. Since he wants to satisfy both sides, he says that the average is not $25,000 or $5,000. Instead, it is $7,500.

Do you know what measure of central tendency Mr. Arby Traitor is using?

The MEDIAN: Organize the salaries from high to low - or from low to high.

100,000
55,000
50,000
10,000
10,000
5,000
5,000
5,000
5,000
5,000

Since there are an even number of items in this set, we take the two middle numbers and find the half-way value between the two. You can simply add the two middle numbers and divide by two to find the MEDIAN.

$$\frac{10{,}000 \quad + \quad 5{,}000}{2} \quad = \quad \$7{,}5000$$

As you can see by the example above, it is important to know what measure of central tendency is being used. Help your students become more conscious of the use and misuse of data.

MEASURES OF CENTRAL TENDENCY

STUDENT WORKSHEET

1. Using the following data, find the MEAN, MEDIAN, and MODE:

40 23 12 56 40
17 78 10 21

2. Using the following measurements of the diameters of widget holes, find the MEAN, MEDIAN, and MODE:

2.62" 3.02" 1.97" 2.96" 3.1"
2.33" 2.7" 2.33"

3. Find the MEAN, MEDIAN, and MODE for this set of data:

7 9 3 1 7 5 4 8

MEASURES OF CENTRAL TENDENCY

TEACHER KEY

1. Using the following data, find the MEAN, the MEDIAN, and the MODE:

40, 23, 12, 56, 40, 17, 78, 10, 21

MEAN: Add up all the values: 297
Divide by the number of items in the set: 9
Answer: 33

MEDIAN: Arrange the numbers in ascending or descending order
10, 12, 17, 21, 23, 40, 40, 56, 78
The middle number is 23
Answer: 23

MODE: Look for the value repeated most often: 40
Answer: 40

2. Using the following measurements of the diameters of widget holes, find the MEAN, the MEDIAN, and the MODE:

2.62" 3.02" 1.97" 2.96" 3.1"
2.33" 2.7" 2.33"

MEAN: Add up all the values: 21.03
Divide by the total number of items: 8
Answer: 2.62875"

MEDIAN: Arrange the values
1.97 2.33 2.33 2.62 2.7 2.96 3.02 3.1
(Students who can not successfully arrange this set of values may be having difficulty in place value. See COMMENTS for further notes.)
Choose the two middle values (since there is no middle number): 2.62, 2.7
Add the two numbers, then divide by 2 to find the midpoint of the two values: 5.32 divided by 2
Answer: 2.66

MODE: From the arrangement above, the mode can be readily seen
Answer: 2.33

COMMENTS: Be sure students understand what " (symbol for inch) stands for. You may want to compare " to ' (symbol for foot).

Measures of Central Tendency

For problems such as #2, students may prefer to use the calculator to find the mean. Before doing so, you may want to give a brief review of how to add with decimals. Remind them that the decimals must be lined up one under the other so that tenths are added to other tenths, etc. If students are not sure what is meant by the term 'tenth', it is advised that you provide practice in reading decimals. You can easily write decimals on the board and ask students to read them after explaining place value. 2.33 is not read "two point three three". Instead encourage students to read it as " two and thirty-three hundredths". For those students who cannot figure the median, it is suggested that time be taken to instruct students in comparisons of decimals (i.e., Is 2.33 the same as 2.330? Is 4.5 the same as 4.05?)

3. Find the MEAN, MEDIAN, and MODE for this set of data:

7 9 3 1 7 5 4 8

MEAN: Add all the values: 44
Divide by the number of items: 8
Answer: 5.5

MEDIAN: Arrange the items:
1 3 4 5 7 7 8 9
Since there is no middle number, add the two middle items: 5 + 7 = 12
Now divide by 2 12 divided by 2 = 6
Answer: 6

MODE: By looking at the arrangement above, we can see that the most common value is 7
Answer: 7

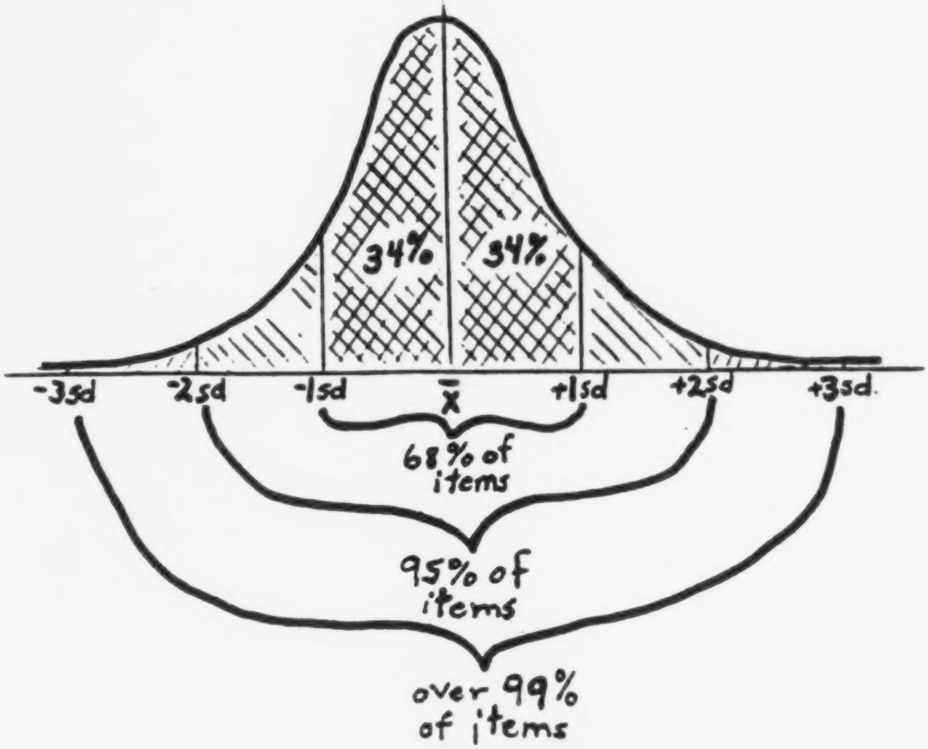
COMMENTS: Be sure students know what to do with a remainder: 8 goes into 44 five times with a remainder of 4. Again, if they have difficulty with place value, they may have difficulty understanding why 44 is the same as 44.0. Do not encourage students to use the calculator until you can see whether they have the concept of place value. Calculators are useful in computing heavy calculation, but they often cover up a lack of 'number sense'. We need to be conscious of how students are solving problems, with or without the use of a calculator.

MEASURES OF DISPERSION

A MEASURE OF DISPERSION describes how much the items or values in a set of data are spread out, or dispersed. The simplest example of a MEASURE OF DISPERSION is the RANGE. The RANGE shows the difference between the extreme values of a set of data (the largest and smallest items). The symbol R is usually used to represent the RANGE. The RANGE is of particular importance in control charts, often used in conjunction with X-Bar charts.

To compute the RANGE of this set of data: 4, 12, 7, 8, 10, and 11, find the largest and smallest items in the set. In this case 12 is the largest and 4 is the smallest. The RANGE is the difference of those two values: 8.

The more commonly used measure of dispersion is STANDARD DEVIATION. STANDARD DEVIATION can basically be described as the percentage of the data that is dispersed around either side of the MEAN. In order to find the standard deviation, each item is compared to the mean of the set of data. We then have an indication of the percentage of items that surround the mean. 68% of the items within a set of data will fall within 1 standard deviation (sd*) on either side of the mean, and 95% of the data will fall within 2 sd's of the mean. Almost 100% (99.73%) of the data will have within 3 sd's of the mean.



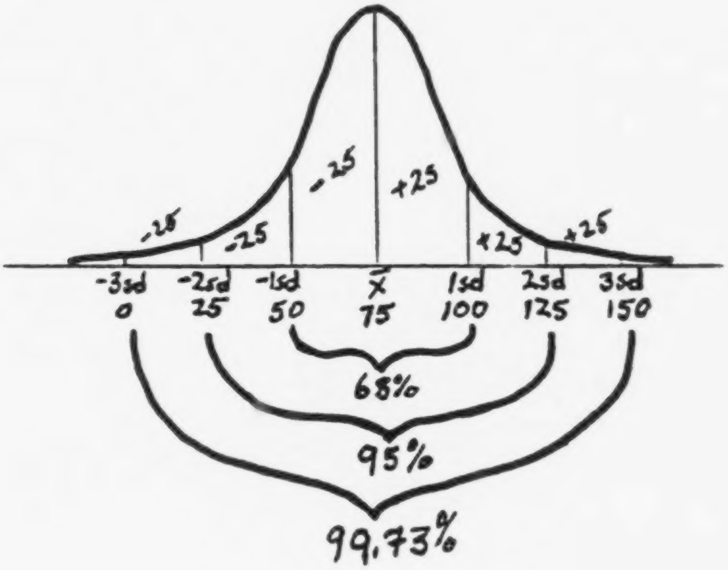
The standard deviation is found by using a fairly involved formula. Your students typically would not be expected to compute the standard deviation for a set of data, but they should understand the concept of sd.
Let's look at an example to further clarify the concept of STANDARD DEVIATION.

Let's say there are 2000 items in a set of data with a mean of 75 and a standard deviation of 25.

From this information, we can tell that 68%, or 1360 items (68% of 2000 = 1360), will fall between 50 (75 - 25) and 100 (75 + 25).

95% of the items (1900), or all but 100 (5%) will fall between 25 (75 - 25 - 25) and 125 (75 + 25 + 25).

99.73% or about 1995 (all but 5 items) will fall between 0 (75 - 25- 25- 25) and 150 (75 + 25 + 25 + 25).



* sd is used when a random sample is taken. The Greek symbol for sigma, σ , is used when all the items of a set of data, known as the population, is used in calculating the standard deviation.

HISTOGRAMS

A histogram is a pictorial representation of a collection of data. It is a type of bar graph which is used to clearly represent a table of information so decisions can be easily made. Typically, companies use histograms to chart the course of one of their processes. They use these charts to help make decisions about the efficiency and quality of the process.

For example:

For one month, Rick recorded how long it took him to get from his house to work. At the end of the month he had the following table of data:

DAY:	1	2	3	4	5	6	7	8	9	10
MINUTES:	20	24	23	21	24	28	33	30	23	25

DAY:	11	12	13	14	15	16	17	18	19	20
MINUTES:	26	25	24	27	26	23	26	28	25	27

DAY:	21	22	23	24	25	26	27	28	29	30
MINUTES:	25	22	29	26	27	25	24	25	22	25

This table is not easily interpreted. It simply looks like a bunch of numbers lumped together. By plotting these pieces of data on a histogram, we can see the meaning of all these numbers.

The steps for making a histogram are as follows:

1. On a piece of graph paper, draw one horizontal and one vertical line which intersect (that point being the "vertex").
2. Label the horizontal line (X axis)"minutes to work". Then label the vertical line (Y axis) "number of trips to work" or simply "frequency".

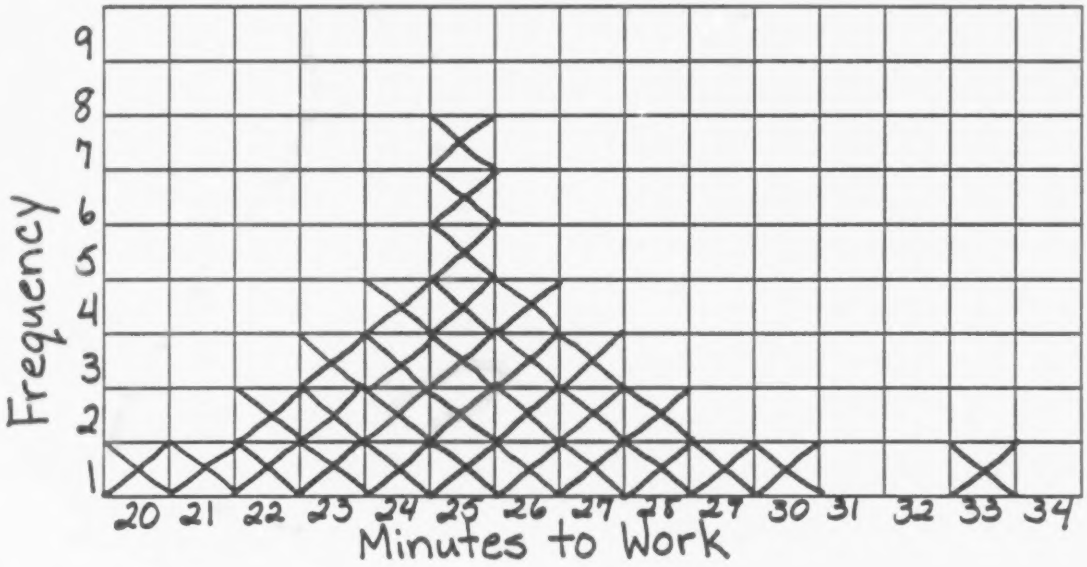
3. By looking at the table, determine the least amount of time it took Rick to get to work (for ease, circle that time in table). Write that value in the first box below the X axis. Then label each box with equal increments until you reach the longest amount of time it took Rick to get to work (again, for ease, find the longest time and circle it in table).

4. Record the data from the table by placing an X in the box corresponding to the correct time. Place the Xs on top of each other. There should be one X for each time period.

5. Write in the consecutive values on the Y axis for the number of occurrences starting at the vertex.

Rick's Road Routine

Your histogram should look like this:



Rick's Road Routine

From this histogram we can easily determine the following:

1. The shortest amount of time it took Rick to get to work = **20 minutes**

   The X furthest to the left denotes the shortest time it took Rick to get to work.
2. The longest amount of time= **33 minutes**

   The X furthest to the right denotes the longest time it took Rick to get to work.

3. What is the central tendency (mean, median & mode) ? **= 25 minutes**
   The central tendency, mean, median and mode all show the center or middle number/value. The middle number\value in this histogram is 25.

   See section called "Central Tendencies" for further details.

4. Were there any abnormal times: a trip that was unusually long or short?= **yes, the 33 minute trip**

   This abnormal amount of time could have been the result of a car accident or some other unusual circumstance that prolonged Rick's trip.

5. The range of the times. That is the difference between the longest amount of time minus the shortest amount of time= **13 minutes**

   The range is calculated as follows: 33 - 20 = 13

   The symbol for range is R.

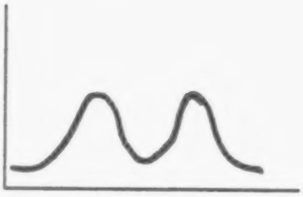
6. Does the histogram represent a process (trips to work) that is in-control or out-of-control?= **in-control**

   A process is in-control if when a sample of the items it produces is plotted on a histogram a bell-shaped, centered curve results.

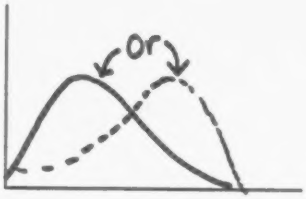
Just from looking at the histogram you can see that the time it took Rick to get to work varied over the thirty day period. Histograms clearly show the variation or the "frequency distribution" that exists in a group of data. They are based on the premise that there is variation in everything: data, processes and every day life.

By outlining the Xs, we can see the shape of a histogram that tells us something about the data we are analyzing. If the histogram resembles a bell, as the example above, it is said to be a normal, bell-shaped curve and the process is said to be in-control. Also, the data varies normally due to common causes. Common cause for the variation in the time it took Rick to get to work could be: traffic, stop lights, rain or any other normal occurrence that would affect his driving time.

Histograms can also be shaped like the example below:



BIMODAL



SKEWED

These histograms denote special causes of variation. There were other factors other than common ones involved in affecting the variation of the data. Typically, when either of these histograms appear, it is a warning that there is abnormal variation and that the process is out-of-control. Therefore, the procedure or process should be investigated.

Companies collect data by random sampling and plot it on histograms in order determine if their processes are in-control or not.

Once again, a process that is in-control depicts a histogram with a bell-shaped curve that is: most of the data points are near the center, there are the same number of points above and below the center, as move away from the center there are fewer and fewer points and there are no data points on the outskirts by themselves.

Rick's Road Routine

STUDENT WORK SHEET

NAME:______________________

DATE:______________________

Directions: From the data in the table below construct a histogram and answer the questions relating to it.

For one month, Rick recorded how long it took him to get from his house to work. At the end of the month he had the following table of data:

DAY:	1	2	3	4	5	6	7	8	9	10
MINUTES:	20	24	23	21	24	28	33	30	23	25

DAY:	11	12	13	14	15	16	17	18	19	20
MINUTES:	26	25	24	27	26	23	26	28	25	27

DAY:	21	22	23	24	25	26	27	28	29	30
MINUTES:	25	22	29	26	27	25	24	25	22	25

Rick's Road Routine

1. What is the shortest amount of time it took Rick to get to work? ____________

2. What is the longest amount of time? ____________

3. What is the central tendency (mean, median & mode)? _____________

4. Were there any abnormal times: a trip that was unusually long or short? ______________

5. What is the range of times? _______________

6. Does the histogram represent a process (trips to work) that is in-control or out-of-control? _______________

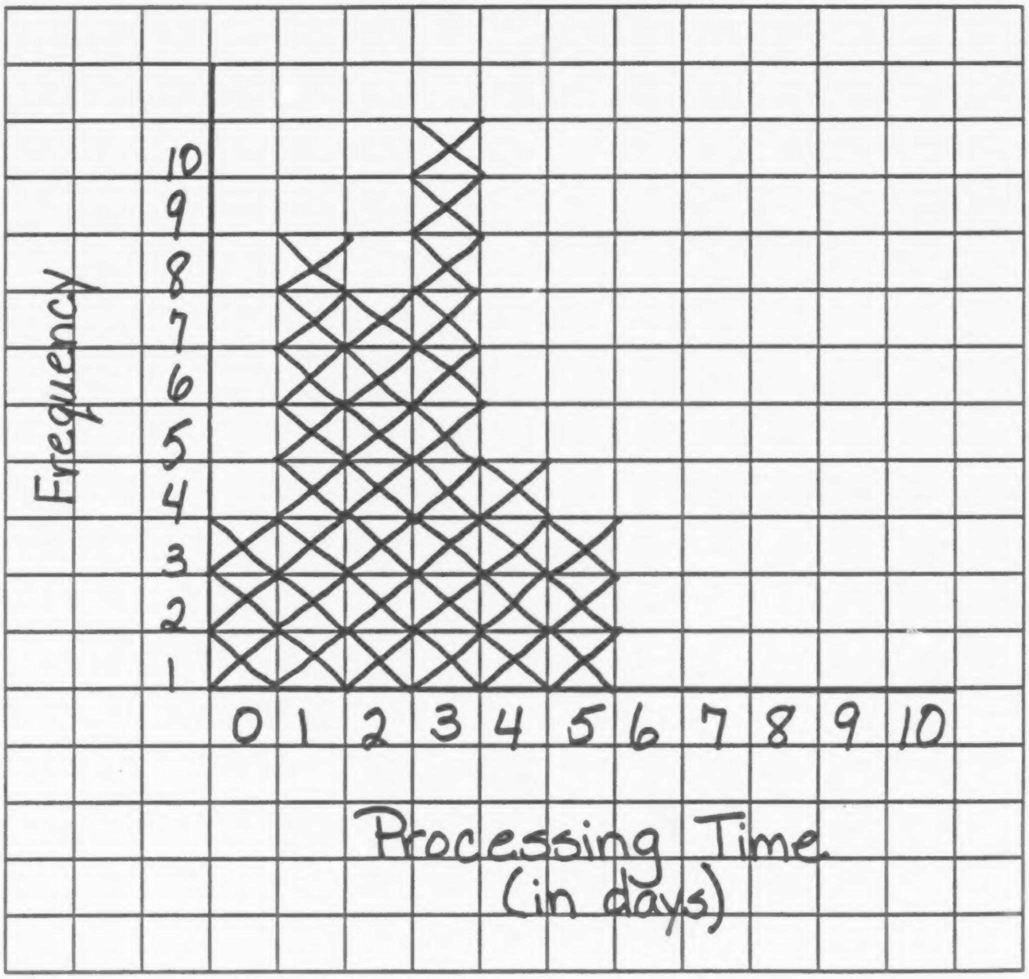
Name:____________________

Date:____________________

P. L. PLASTICS CO.

TIME IN PROCESSING ORDERS

STUDENT WORK SHEET



P. L. PLASTICS CO.
TIME IN PROCESSING ORDERS

STUDENT WORK SHEET

Directions: Answer the following questions based on the histogram on the previous page.

1. What was the maximum amount of days it took the company to process an order? ____________

2. What was the minimum number of days it took the company to process an order?

   ____

3. The company's goal is to process an order in three days or less. What percentage of all the orders in the month of June met this goal?

   ____

4. What is the mode?

   ____

5. What is the R?

   ____

6. What is the $\overline{X}$?

   ____

7. What is the median number of days it takes to process an order?

   ____

8. This histogram represents a (bell-shaped, skewed or bimodal) curve.

9. Does this histogram represent a process that is in-control or out-of-control ?

   ____

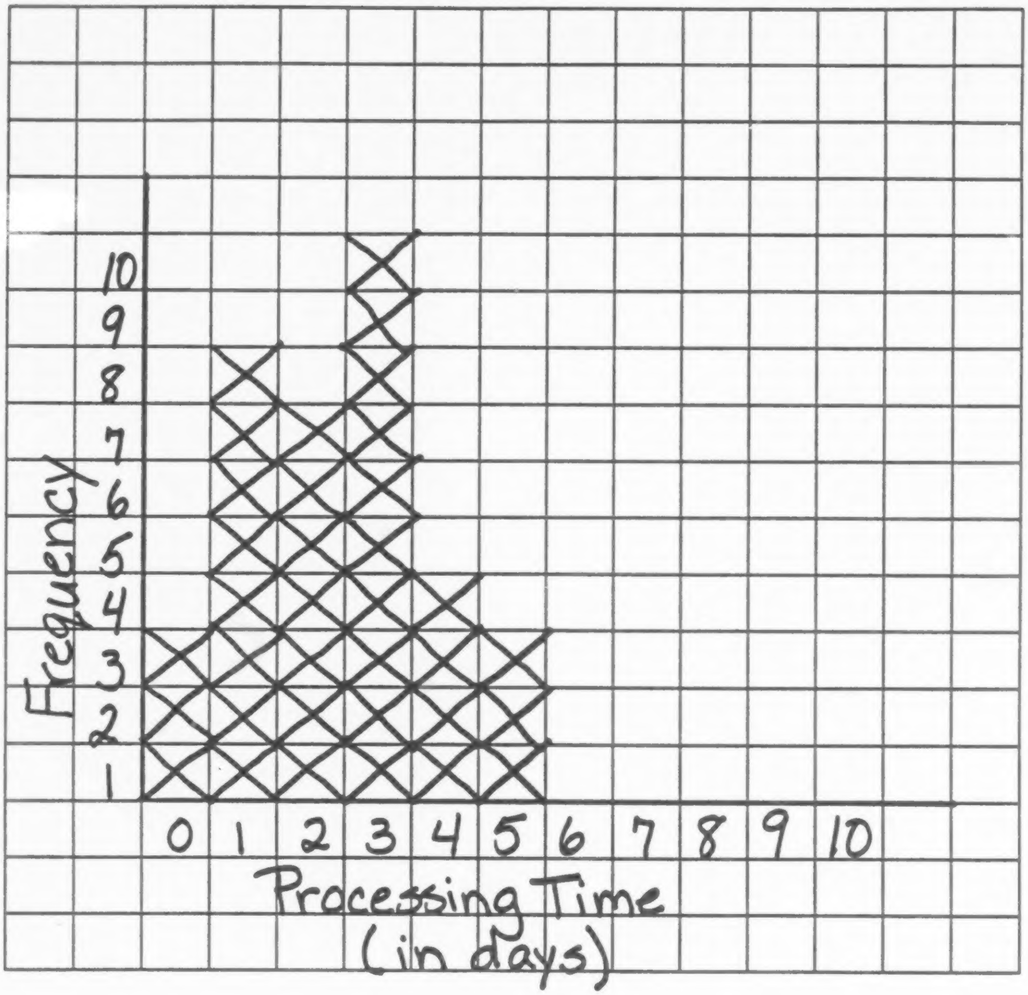
10. Is this a stable process? Why or Why not?

    ____

    ____

P. L. PLASTICS CO.
TIME IN PROCESSING ORDERS

TEACHER KEY



P. L. PLASTICS CO.
TIME IN PROCESSING ORDERS

TEACHER KEY

Directions: Answer the following questions based on the histogram on the previous page.

1. What was the maximum amount of days it took the company to process an order? **5**

2. What was the minimum number of days it took the company to process an order? **0**

3. The company's goal is to process an order in three days or less. What percentage of all the orders in the month of June met this goal? **80%**

   There were 28 orders that were processed in three days or less. Place this number over the total number of orders which is 35. (28/35) Divide and then multiply by 100 (28 35 = .8, .8 x 100 = 80). The answer you come up with is the percent (80%).

   If your students have problems determining this answer review the material on percent circles.

4. What is the mode? **3**

   Remember that the mode is the most frequently occurring value.

5. What is the R? **5**

   The range is the highest value minus the lowest value: 5 - 0 = 5

6. What is the $\overline{X}$? **3**

   The mean is the same as the mode and median.

7. What is the median number of days it takes to process an order? **3**

   (See explanation above.)

P. L. PLASTICS CO.

TIME IN PROCESSING ORDERS

8. This histogram represents a (bell-shaped, **skewed** or bimodal) curve.

   This is difficult to say. It would be ideal to have a larger sample of data plotted in order to get a more precise picture of the pattern of variation. However, most of the data points are on the right side of the central tendency. Therefore the histogram is not a symmetric, bell-shaped curve nor is it bimodal. It is skewed.

9. Does this histogram represent a process that is in-control or **out-of-control** ?

   Since this histogram does not represent a normal, bell-shaped curve, it is not in-control.

10. Is this a stable process? Why or Why not? **No**

    In order for a process to be stable it must show a normal and a centered pattern of variation. This process does not.

CONTROL CHARTS

Control charts are tools of SPC. They are a type of line graph that tells us if our process is in control and if it is running within acceptable limits. Control charts were invented by Dr. Walter Shewhart of Bell Laboratories in the 1930's. He based them on the normal curve. In this way unusual or excessive variation in a process can easily be detected.

Control charts show changes in a process overtime. That is, they indicate unusual patterns which can occur in an on going process.

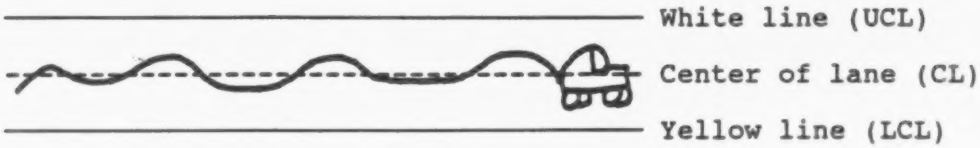
Control charts consist of three lines: a center line (CL), an upper control limit (UCL), and a lower control limit (LCL). The CL represents the mean $(\overline{X})$. The UCL and the LCL represent the boundaries of normal variation. The UCL represents the maximum variation to be expected from a process that is functioning with only normal causes present. The LCL represents the minimum variation expected from a process when it is functioning with only normal causes present.

The vertical axis of a control chart is typically label with the specification or requirement the company desires to monitor. For example, the Figit Company makes Gigits that must be one inch in diameter. Figit's QC people construct control charts with the vertical labeled "Diameters-in inches".

The horizontal axis is usually labeled the" Subgroup or Sample Number". This is simply the number assigned to each sample that was taken during the process that is being monitored. To contiue our example above, the horizontal axis of that control chart would be labeled "Sample Number" representing each Gigit sample that was taken to check diameters.

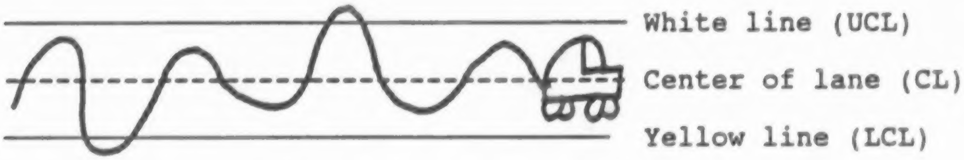
An everyday example which may help your students to understand control charts is the driving pattern of a sober and a drunk driver. A sober driver drives in the center of the lane and usually never crosses over the white or yellow lines. His pattern is a normal and controlled. Any variation that does occur in his pattern is due to normal causes such as bumps, branches, other debris in the road, a momentary break in the driver's concentration, etc.

DRIVING PATTERN OF A SOBER DRIVER


White line (UCL)
Center of lane (CL)
Yellow line (LCL)

A drunk driver, on the other hand, has an abnormal driving pattern. Frequently, she crosses over the white and yellow lines. Her pattern is erratic and out of control!! This variation is not due to common causes but due to special causes, especially an abundance of alcohol.

DRIVING PATTERN OF A DRUNK DRIVER


White line (UCL)
Center of lane (CL)
Yellow line (LCL)

Control charts can only warn us of special causes of variation if there is something causing a process to be out of control. They are not designed to find the causes of variation nor can they control them. If control charts are used correctly, they can monitor a process and signal as soon as something unusual occurs. Then the process should be adjusted in order to eliminate the the abnormal variation.

Data on a process must continually be plotted on a control chart so the process itself can be carefully monitored. Typically, quality control personnel are responsible for creating and maintaining control charts. However, it will be beneficial for you and your students to know how to read and interpret the ones used in your company.

Control charts show patterns of variation. Therefore it is important to be able to recognize those patterns that show when a process is in-control and when it is out-of-control. When a process is in-control all the data points on a control chart fall between the upper and lower control limits.

When a process is out-of-control one or more data points falls outside of the control limits or one of these two patterns appears: a trend and a run or shift. In simple terms, a trend is when there are at least seven consecutive data points on a control chart that are heading in either a downward or upward direction. A run or shift is when there are at least seven consecutive data points on a control chart that fall between the center line (CL) and one of the control limits (UCL or LCL).

The definitions of patterns that show that a process is in-control and patterns that indicate that a process is out of control ie: trends or runs/ shifts, vary from company to company. So, we recommend that a teacher contact their company quality control personnel to determine what standards they adhere to.

An example of a control chart is included on the following pages. This is simple chart that will help to reinforce the basic concepts explained above. However, we do once again recommend that you find out which control charts your company uses and teach your students how to interpret them.

NAME:____________________

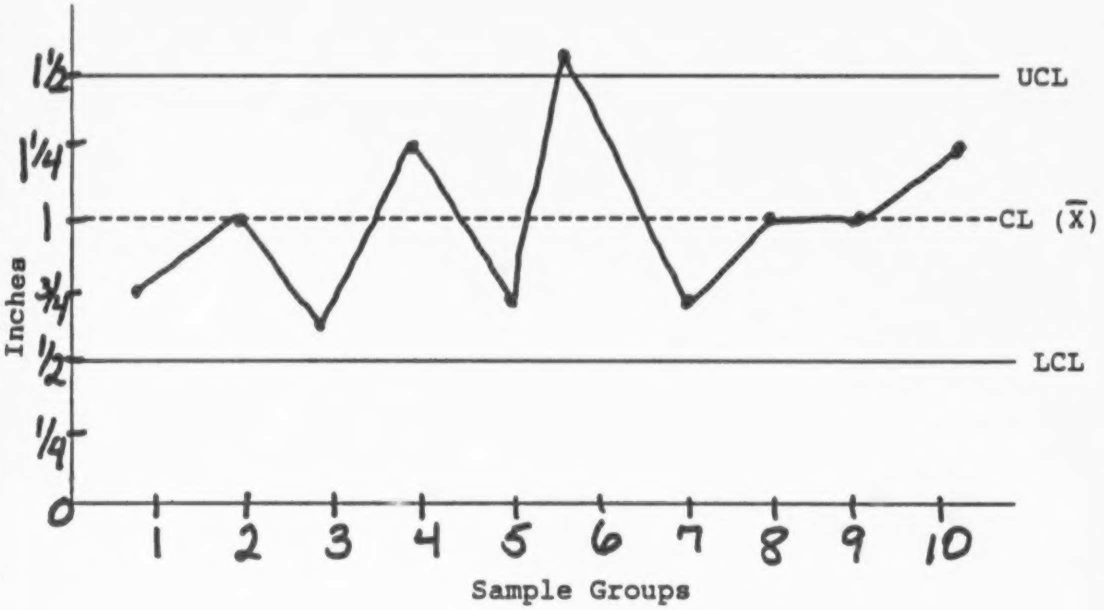
DATE:____________________

Figit's Gigits
Control Chart

STUDENT WORK SHEET

Directions: Read the following control chart carefully. Then answer the questions that follow.

Gigit Diameters



Figit's Gigits
Control Chart

1. What process does this control chart monitor?

____

2. What is the upper control limit?

____

3. What is the lower control limit?

____

4. What is the mean?

____

5. Is this process in-control? Why or why not?

____

____

6. Is this process out-of control? Why or why not?

____

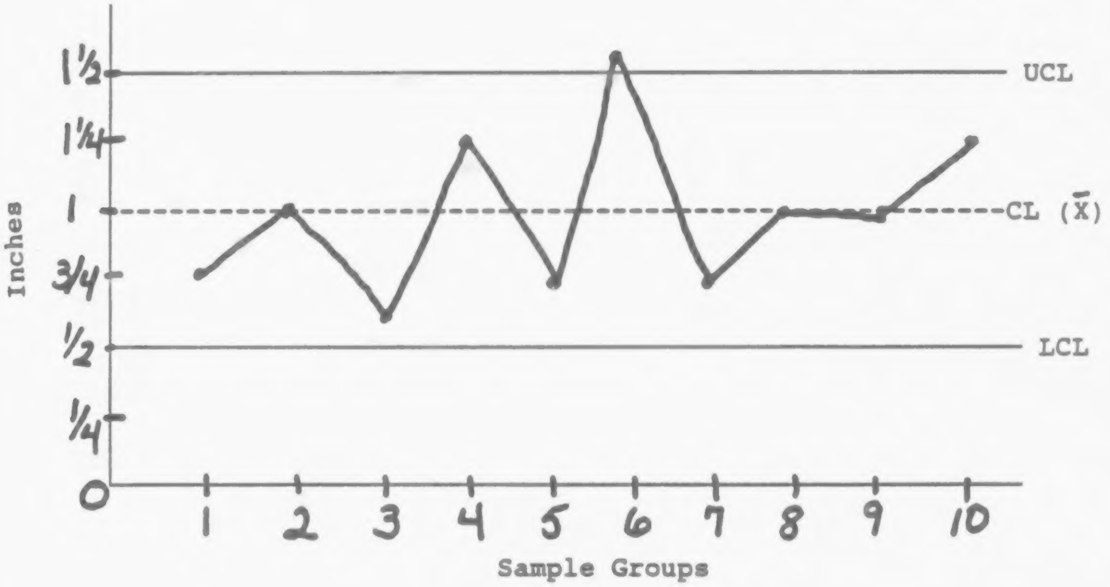
____

Figit's Gigits Control Chart

TEACHER KEY

Directions: Read the following control chart carefully. Then answer the questions that follow.

Gigit Diameters



1. What process does this control chart monitor?

   This chart monitors the process of making Gigits-specifically monitoring the diameters of the Gigits

2. What is the upper control limit?

   The upper control limit (UCL) is 1 1\2 inches.

Figit's Gigits Control Chart

3. What is the lower control limit?

   The lower control limit (LCL) is 1/2 inch.

4. What is the mean?

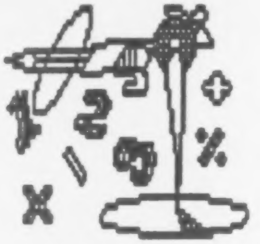
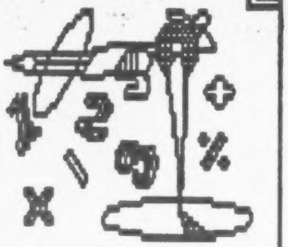
   The mean ($\bar{X}$) is represented by the center line (CL) which is 1 inch.

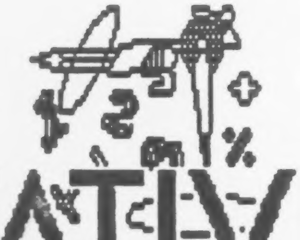
5. Is this process in-control? Why or why not?

   This process is not in control because it has a point which is outside the upper control limit.

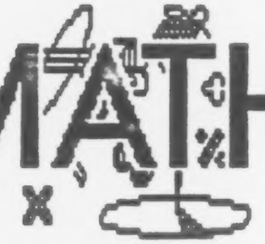
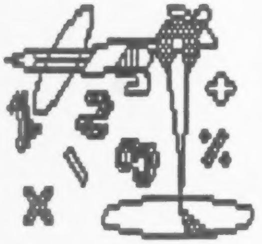
6. Is this process out-of control? Why or why not?

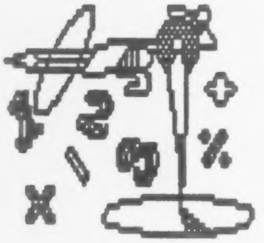
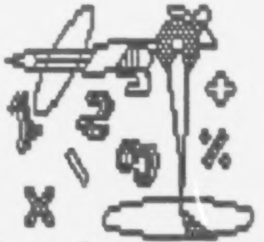
   This process is out-of-control because it has a data point which is out of the upper control limit.

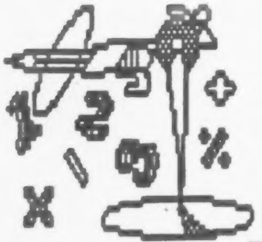





QUALITATIVE MATH



MENTAL MATH

We traditionally teach math the way that we learned it: by following rules and patterns. Unfortunately, if we forget the rule or pattern, we're suddenly lost and have to come up with our own method of solving the problem.

Adults have a store of strategies for solving problems. It is important in a classroom setting that students share their strategies. After all, there is no one right way to solve a problem. Sometimes another student's strategy is better understood by others rather than the teacher's suggested techniques.

Fractions, decimals, and percents are used on a regular basis by adults. Whether it's looking at bargain items ("1/2 off"), considering buying a new car ("only 10% down"), or analyzing statistics at work ("our goal is 99.74% quality items"), we cannot avoid fractions, decimals, and percents.

Adults typically are not asked to add or subtract fractions in life or work-related situations. Therefore, unless there is a specific need, we suggest instructors not bother with teaching students how to find common denominators, greatest common multiples, etc. Instead, efforts should be concentrated around solving word problems involving fractions, decimals, and percents as well as changing from one form to another.

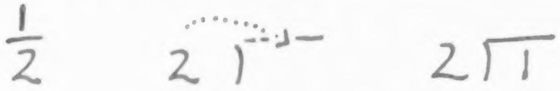
Yes, a calculator can be very useful in computing, but students need some background knowledge before a calculator can be helpful. The following sections offer some strategies to help student gain a number sense about fractions, decimals, and percents. Once they have a sense about what the solution should look like, the calculator can be used to solve more difficult problems. Students will then have the number sense to know if the calculator's solution is a reasonable answer to a given problem.

Adults should be able to figure out 1/2 of an amount in their heads. Use money as the initial instruction if students cannot already figure 1/2 mentally. Ask students what 1/2 of a dollar is; 1/2 of ten cents. When students respond correctly, ask them how they derived at the answer. "What did you do in your head?" The answer typically is, "I divided by two."

Now expand to other numbers. A coat that normally sells for $200 is 1/2 off. What would it cost? Give plenty of practice for students to divide in their heads. They need this initial success to have enough confidence to continue to be willing to try mentally solving math.

Expand to 1/4 and 1/3. Let them try problems mentally, then encourage them to share their strategies for solving the problems. Worksheet M1 can be used to develop mental math skills. Also, all the Pareto charts used in this book (including the extra sample) can be used to encourage mental math thinking.

Students are aware that half a dollar is the same as $.50 and a quarter (1/4) is equal to $.25. Now is a good time to show students the process for changing from fractions to decimals. Most students will probably have no idea, yet they can equate 1/2 to .5 and 1/4 to .25. The / mark tells you that you can divide the two numbers. But which number goes into which number? (When they were in grade school, many students were taught that "the smaller number always goes into the larger number". As adults, we know this is not true.) Students who cannot remember which number is which may feel more confident if they are told that the bottom number (the denominator) stays put, but the top number (the numerator) is top-heavy so it falls over. Thus, the problem is ready to be calculated.



Once students understand how fractions can be changed to decimals, the calculator can be introduced for changing more difficult fractions into decimals. Again, don't assume that once you put a calculator into a student's hands that your job is done. Students need to be shown how to operate a calculator. 1/2 tells you that 1 is divided by 2, or 1 ÷ 2. Therefore, in using the calculator, the student needs to enter 1/2 as 1 ÷ 2 = .5. Students should be encouraged to try to solve problems as often as possible mentally. To double-check, the calculator can be used. As students gain confidence in dealing with typical fractions (1/2. 1/4, 1/3, 3/4, 2/3, 1/5, 1/10), they should depend less and less on the calculator for support.

Many students have no idea of what 10% or 1/10 of a number is. Again, begin with money: "What is the relationship between a penny and a dime?" "A dime and a dollar?" Help students see what 1/10 or 10% represents. Use whole numbers involving a zero in the one's place first (What is 1/10 of 200? 350?) The same technique for finding 1/2 (Remember: Divide by 2.) is used to find 1/10 of a number. If students don't see the pattern of moving the decimal one place to the left, work the problems out on the board until they begin to see a pattern.

$\frac{1}{10}$ of $50 = 5.0$ $\quad$ $1/10$ of $100 = 10.0$

$1/10$ of $75 = 7.5$ $\quad$ $1/10$ of $89 = 8.9$

As student see what happens when a number is divided by 10, challenge their thinking by asking them to solve problems without a zero in the one's place (What is 1/10 of 45? 61? 4???) Worksheet M2 can be used to give students more practice in dealing with 1/10 and 10%.

Expand now to 20% of a number, then 30%, 25%. Copies of fliers offering discounts offer great examples for practice. This type of mental math involves more than one step. With enough practice and support, student should be able to readily solve problems such as this. Use the 15% expected tip as a real-life example of how to calculator percentages mentally. Worksheet M3 gives students a chance to practice mental math. Encourage students to solve the complete problem in their heads.

As problems become increasingly difficult, other strategies are needed. The percent circle is a simple graphic way to set up problems. A visual such as this is the first step in solving more difficult problems. A calculator is useless unless a student knows how to set up the problem, when to multiply or divide, and which number to divide into which number. The percent circle helps students set up the problems so that they know whether to multiply or divide as well as which number to divide into what. Although worksheet M4 provides more practice for students, we encourage you to use real life situations with your students.

MENTAL MATH
WORK SHEET M1

Use 'mental math' to solve each of the problems on this page:

1. A store is offering a 1/3 - off sale on all items.

   a) What is the sale price of a table regularly selling for $90.00?

   b) How much would you save on a couch that usually sells for $240.00?

2. Of a total of 200 employees at Kirry Industries, 1/5 are typesetter and 1/4 are data researchers.

   a) How many employees are typesetters?

   b) How many are not data researchers?

3. There are 66 dogs in the County Kennel. One-half are mixed breed, and the rest are purebreds. Also, out of all the dogs, 1/6 have long tails.

   a) How many are not purebred?

   b) How many have long tails?

   c) If one-third of the dogs went to good homes, how many would then be left?

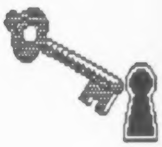
4. Poor's Department Store is having a summer sale. Men's T-shirts are 1/2 off. Ladies' tennis shorts are 1/3 off.

   a) How much would you pay for two T-shirts that regularly cost $4.50 each?

   b) How much would you pay for three T-shirts normally costing $4.50 each?

   c) If ladies' tennis shorts usually sell for $6.00, how much would you save on one pair?

   d) If you bought 3 pairs of $6.00 shorts, how much would you pay?



MENTAL MATH
WORK SHEET M1
TEACHER KEY

Use 'mental math' to solve each of the problems on this page:

1. A store is offering a 1/3 - off sale on all items.

   a) What is the sale price of a table regularly selling for $90.00? **($60)**

   b) How much would you save on a couch that usually sells for $240.00? **($80)**

2. Of a total of 200 employees at Kirry Industries, 1/5 are typesetter and 1/4 are data researchers.

   a) How many employees are typesetters? **(40)**

   b) How many are not data researchers? **(150)**

3. There are 66 dogs in the County Kennel. One-half are mixed breed, and the rest are purebreds. Also, out of all the dogs, 1/6 have long tails.

   a) How many are not purebred? **(33)**

   b) How many have long tails? **(11)**

   c) If one-third of the dogs went to good homes, how many would then be left? **(44)**

4. Poor's Department Store is having a summer sale. Men's T-shirts are 1/2 off. Ladies' tennis shorts are 1/3 off.

   a) How much would you pay for two T-shirts that regularly cost $4.50 each? **($4.50)**

   b) How much would you pay for three T-shirts normally costing $4.50 each? **($6.75)**

   c) If ladies' tennis shorts usually sell for $6.00, how much would you save on one pair? **($2.00)**

   d) If you bought 3 pairs of $6.00 shorts, how much would you pay? **($12.00)**

MENTAL MATH
WORK SHEET M2

Very quickly, using 'mental math', find 10% of each number below:

1) 110 ____________

2) 4930 ____________

3) 22 ____________

4) .9 ____________

5) 2 ____________

6) 876 ____________

7) 65 ____________

8) 213 ____________

9) 40 ____________

10) 1 ____________

11) 2.3 ____________

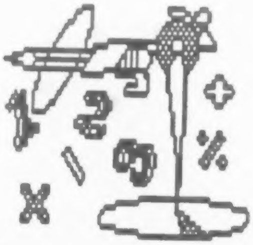
12) 360 ____________

13) 5 ____________

14) 78.3 ____________

15) .05 ____________

16) .342 ____________



MENTAL MATH
WORK SHEET M2
TEACHER KEY

Very quickly, using 'mental math', find 10% of each number below:

1) 110 **11**

2) 4930 **493**

3) 22 **2.2**

4) .9 **.09**

5) 2 **.2**

6) 876 **87.6**

7) 65 **6.5**

8) 213 **21.3**

9) 40 **4**

10) 1 **.1**

11) 2.3 **.23**

12) 360 **36**

13) 5 **.5**

14) 78.3 **7.83**

15) .05 **.005**

16) .342 **.0342**

MENTAL MATH
WORK SHEET M3

Use 'mental math' to solve each of the problems below:

1. Jack's Junk Shop is selling items for 30% off this week only.
   a) What is the sale price of a used stove normally selling for $100.00?
   b) What is the sale price of a wooden ladder normally selling for $50.00?

2. Drew's Drapery Factory offers a discount of 25% if a customer buys more than one set at a time.
   a) What is the cost of 10 sets of draperies that usually sell for $20 each?
   b) How much would you save on $25.00 drapes if you bought four sets?

3. What would be the expected tip (15%) on a meal costing $30.00?

4. Dave's Deli is going out of business so it is selling all food for 50% off and all furniture for 20% off.
   a) What would you pay for 3 jars of dill pickles each selling for $2.50?
   b) What would you pay for 4 stools if they normally cost $80.00 for a set of four?
   c) How much would you save on a jar of olives usually selling for $3.00 and a corner bench that normally sells for $30.00?

5. What is 26% of 400? (Think: 25% + 1% = 26%)

6. What is 35% of 600? (Think: 10% X 3 + 5% = 35%)

MENTAL MATH
WORK SHEET M3
TEACHER KEY

Use 'mental math' to solve each of the problems below:

1. Jack's Junk Shop is selling items for 30% off this week only.

   a) What is the sale price of a used stove normally selling for $100.00? **($70)**

   b) What is the sale price of a wooden ladder normally selling for $50.00? **($35)**

2. Drew's Drapery Factory offers a discount of 25% if a customer buys more than one set at a time.

   a) What is the cost of 10 sets of draperies that usually sell for $20 each? **($150)**

   b) How much would you save on $25.00 drapes if you bought four sets? **($25)**

3. What would be the expected tip (15%) on a meal costing $30.00? **($4.50)**

4. Dave's Deli is going out of business so it is selling all food for 50% off and all furniture for 20% off.

   a) What would you pay for 3 jars of dill pickles each selling for $2.50? **($3.75)**

   b) What would you pay for 4 stools if they normally cost $80.00 for a set of four? **($64.00)**

   c) How much would you save on a jar of olives usually selling for $3.00 and a corner bench that normally sells for $30.00? **($7.50)**

5. What is 26% of 400? (Think: 25% + 1% = 26%)

   (100 + 4 = 104)

6. What is 35% of 600? (Think: 10% X 3 + 5% = 35%)

   (60 x 3 = 180; 5% = 30; 180 + 30 = 210)

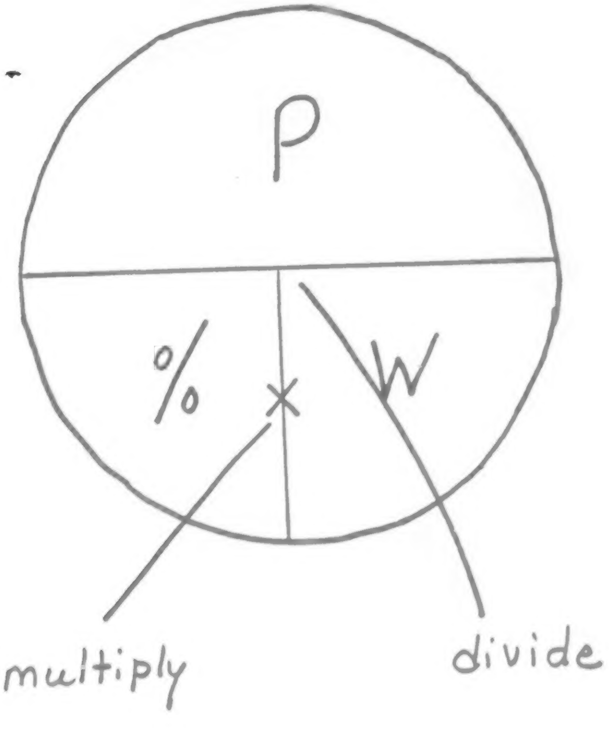
THE PERCENT CIRCLE

The Percent Circle can be used to find the PART, the WHOLE, and the PERCENT. It is especially useful for those who have difficulty deciding when to multiply (to find the part) or divide (to find the percent or the whole).

In the Percent Circle, % stands for PERCENT (or how much of the whole you are taking). Remember: to solve any problem involving a percent, you must first change the percent to a decimal.)

P stands for PART (or what you get when you take a percent of the whole).

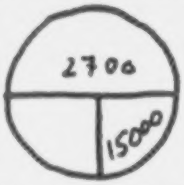
W stands for WHOLE (or what you begin with before you take a part of it).



The following three examples show how to use the Percent Circle to solve problems.

1. To find the PERCENT:
   Mrs. Jones bought a new car for $15,000. She needed a down payment of $2700. What percent did she need to put down?

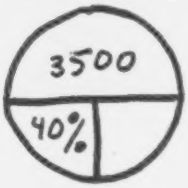
   To solve, place $15,000 in the WHOLE area. The $2700 down payment represents the PART, so place it in the PART area. The circle now looks like this:



$$\frac{2700}{15000} \qquad 15000\,\overline{)\,2700}$$

2. To find the WHOLE:
   3500 employees live in the greater Boston area. If this represents 40% of the employees, how many employees are there altogether?

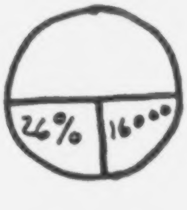
   3500 represents only PART of the population so place it in the PART area. Obviously, 40% goes in the PERCENT area (Don't forget to change the 40% to a decimal.) The circle should look like this:



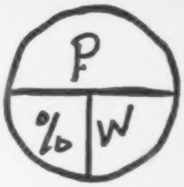
$$\frac{3500}{.40} \qquad .40\,\overline{)\,3500}$$

3. To find the PART:
   Of the 16,000 students attending classes a Smyth Community College, 26 % work part-time. How many student work part-time?

   16,000 represent the WHOLE. The 26% (change to a decimal) should be placed in the PERCENT area. The circle looks like this:



$$.26 \times 16{,}000$$



THE PERCENT CIRCLE
WORKSHEET M4

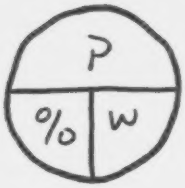
1. A jacket originally selling for $40 was on sale for 15% off the original price. How much is saved by buying the jacket on sale? (Try this problem in your head first.)

2. Mr. and Mrs. Shin need $8000 for a down payment on a house. So far they have saved $6000. What percent of the total amount have they saved?

3. Alfredo earns $250 a week. His employer deducts 12% of his earning for taxes and social security. How much is deducted from Alfredo's weekly pay?

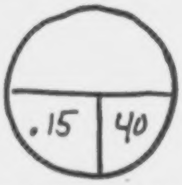
4. John now weighs 172 pounds. This is 80% of what John weighed a year ago. How much did John weigh a year ago?

5. Fiona makes $600 a month and pays $150 a month for rent. Rent is what percent of her income?



THE PERCENT CIRCLE
WORKSHEET M4

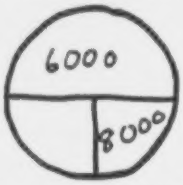
1. A jacket originally selling for $40 was on sale for 15% off the original price. How much is saved by buying the jacket on sale? (Try this problem in your head first.)



$.15 \times 40 = \$16$

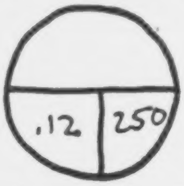
(What is 10% of 40?
...4
What is half of that-
5%? ... 2   4+2=$6)

2. Mr. and Mrs. Shin need $8000 for a down payment on a house. So far they have saved $6000. What percent of the total amount have they saved?



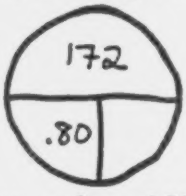
$\frac{6000}{8000} = \frac{6}{8} = \frac{3}{4} = 75\%$

3. Alfredo earns $250 a week. His employer deducts 12% of his earning for taxes and social security. How much is deducted from Alfredo's weekly pay?



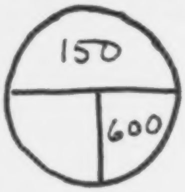
$.12 \times 250 = \$30$

4. John now weighs 172 pounds. This is 80% of what John weighed a year ago. How much did John weigh a year ago?



$\frac{172}{.80} = .80\overline{)172} = 215$

5. Fiona makes $600 a month and pays $150 a month for rent. Rent is what percent of her income?



$\frac{150}{600} = \frac{15}{60} = \frac{1}{4} = 25\%$

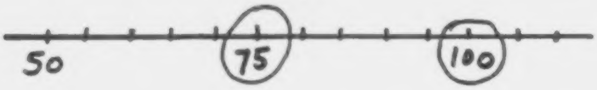
CALIBRATIONS

Students often have difficulty reading charts and graphs because they cannot estimate and/or interpret calibrated marks. This section may be valuable for those students that seem to be lost when it comes to interpreting and estimating points on charts and graphs.

Most people read marks by observing and making a logical guess. For those that do not have a number sense for calibrations, the following 5 steps* may be useful:

1. Find two numbers.

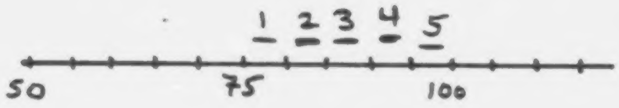
75 and 100



2. Find the difference between those two numbers.

$100 - 75 = 25$

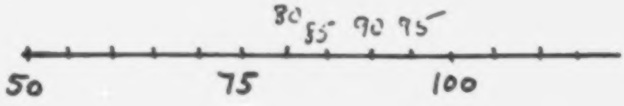
3. Count the number of parts between the two numbers (Don't count the marks, count the sections.)



4. Figure out the amount of each section by dividing the difference between the two numbers by the number of sections.

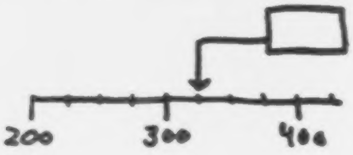
$25 \div 5 = 5$

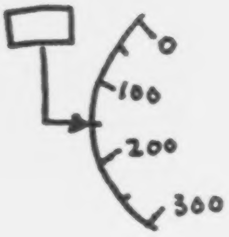
5. Begin at the first number and add the value of each section.

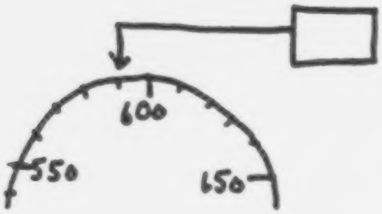


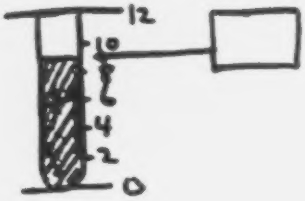
CALIBRATIONS
STUDENT WORK SHEET

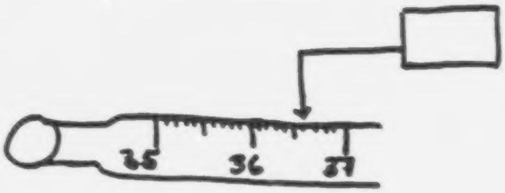
For each visual, write the value that each arrow is pointing to.

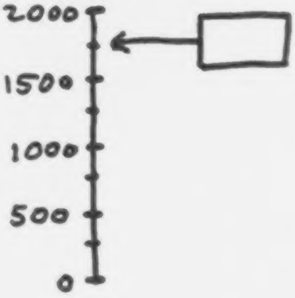



0
100
200
300








2000
1500
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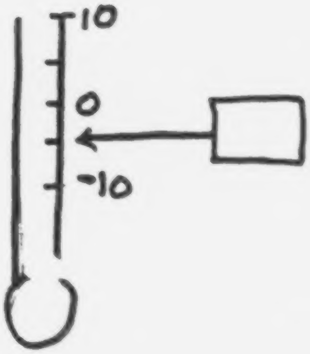

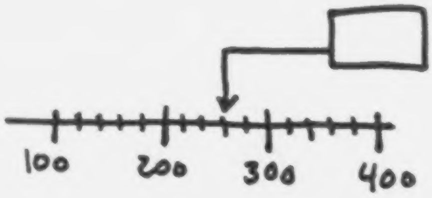
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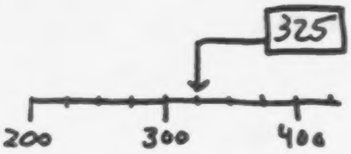
CALIBRATIONS
STUDENT WORK SHEET

For each visual, write the value that each arrow is pointing to.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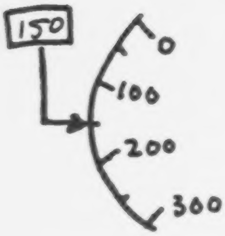
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100
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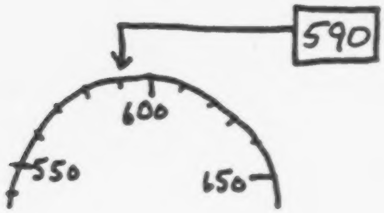
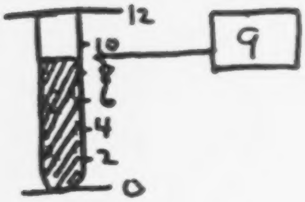
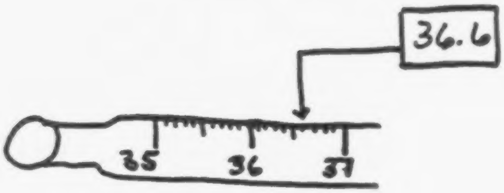
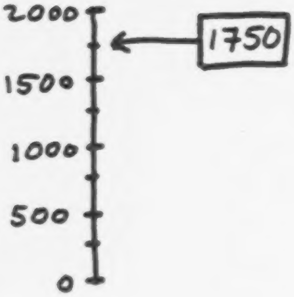
300


590
600
550
650


12
10
8
6
4
2
0
9

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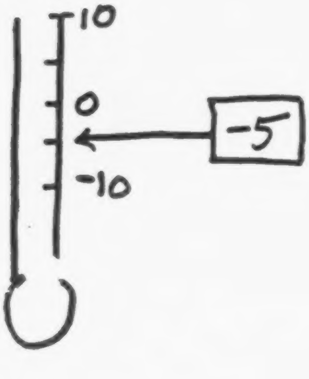

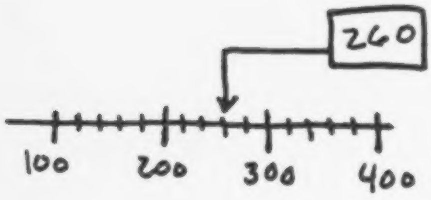
260
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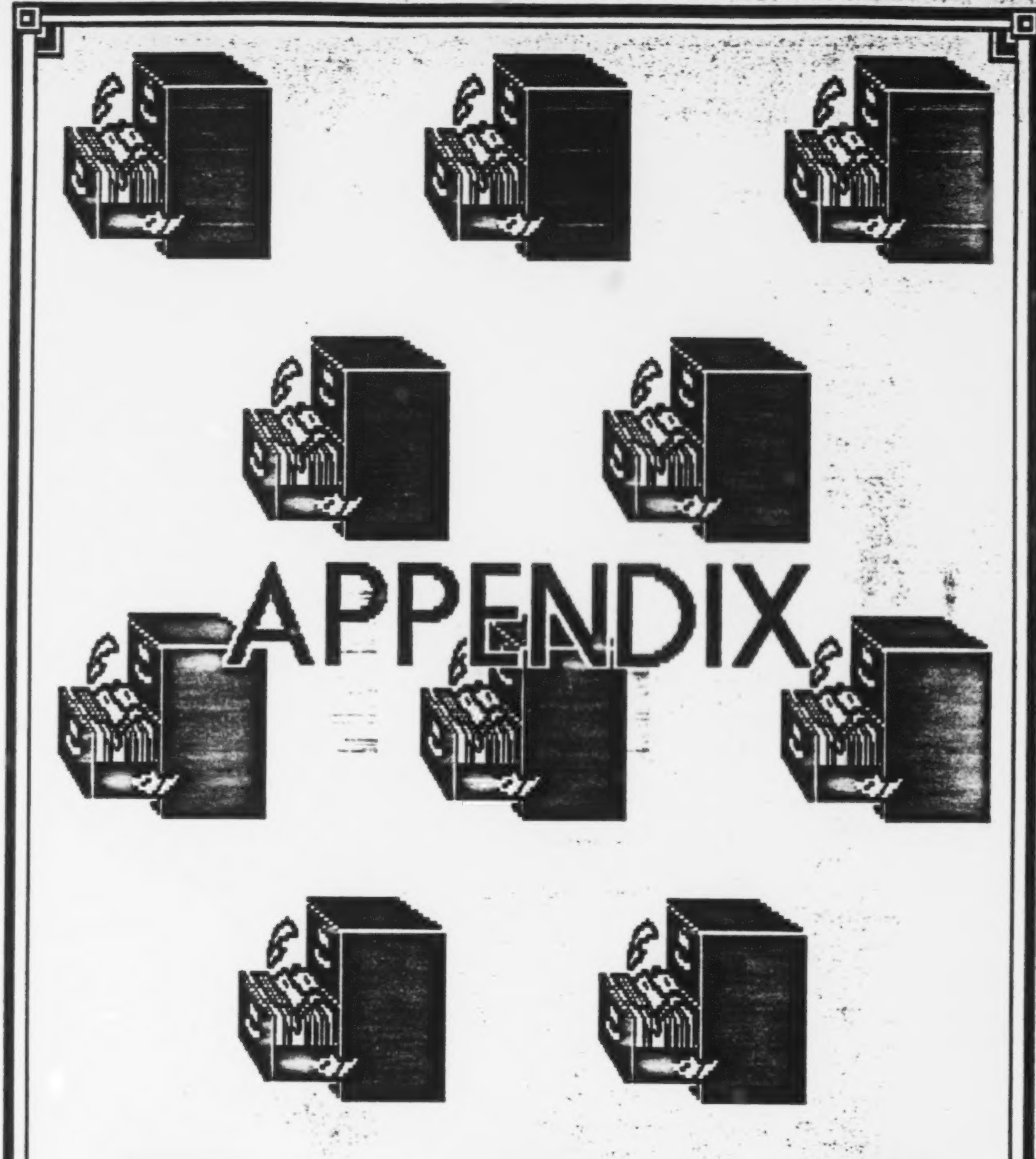
APPENDIX



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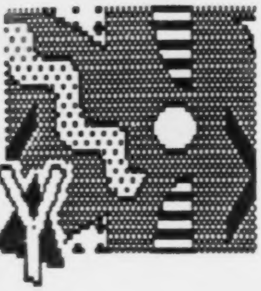


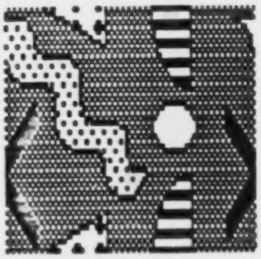
QUALITY

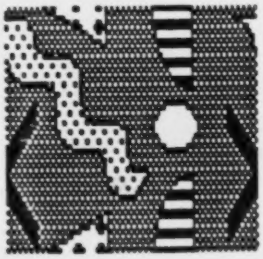
BEANO

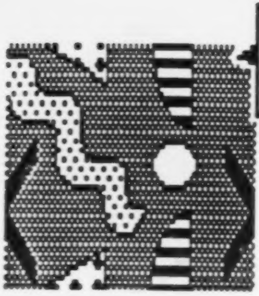
Materials: BEANO cards (Copy the next page and glue onto tagboard.), list of QUALITY vocabulary (We have provided a suggested list on page 100.), chips or small pieces of paper to use as markers.

Purpose: To practice sight word recognition

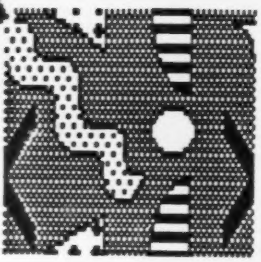
Directions: After defining the QUALITY vocabulary as a class, distribute blank BEANO cards. Each student makes his/her own card with the vocabulary given. Collect the cards, mix them up, and pass them out. It would be beneficial for the instructor to write the vocabulary words on index cards ahead of time. Then he/she can call them out randomly. BEANO is played using the same rules as BINGO. The instructor or the students can determine how the game is won.

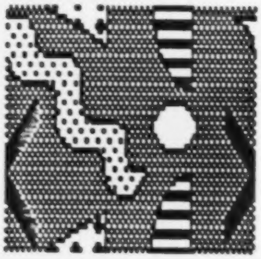




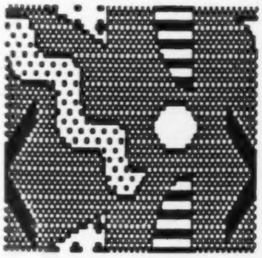


BEANO





CARD



quality
consumer
manufacturer
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effect
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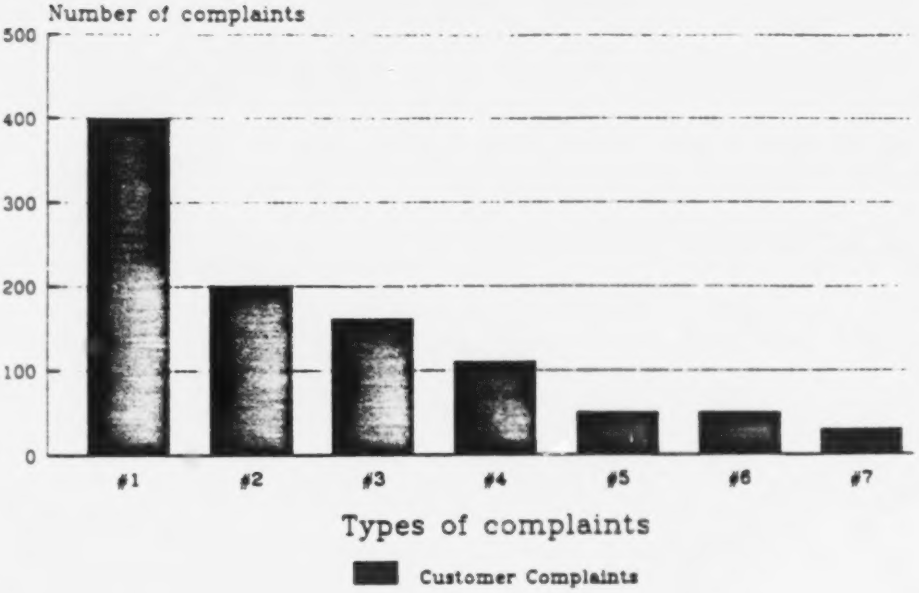
specification
variable
exceed
customer
cause
variation
histogram
median
frequency
subjective data
special cause
control chart
population
LCL

flow chart
process flow
process
out of control
in control
Pareto
mean
histogram
SPC
requirements
strive
TQC
concentration
range
Pareto chart
mode
countable data
common cause
standard deviation
sampling
ULC
central tendency

Home Health Care Service

Customer Complaints

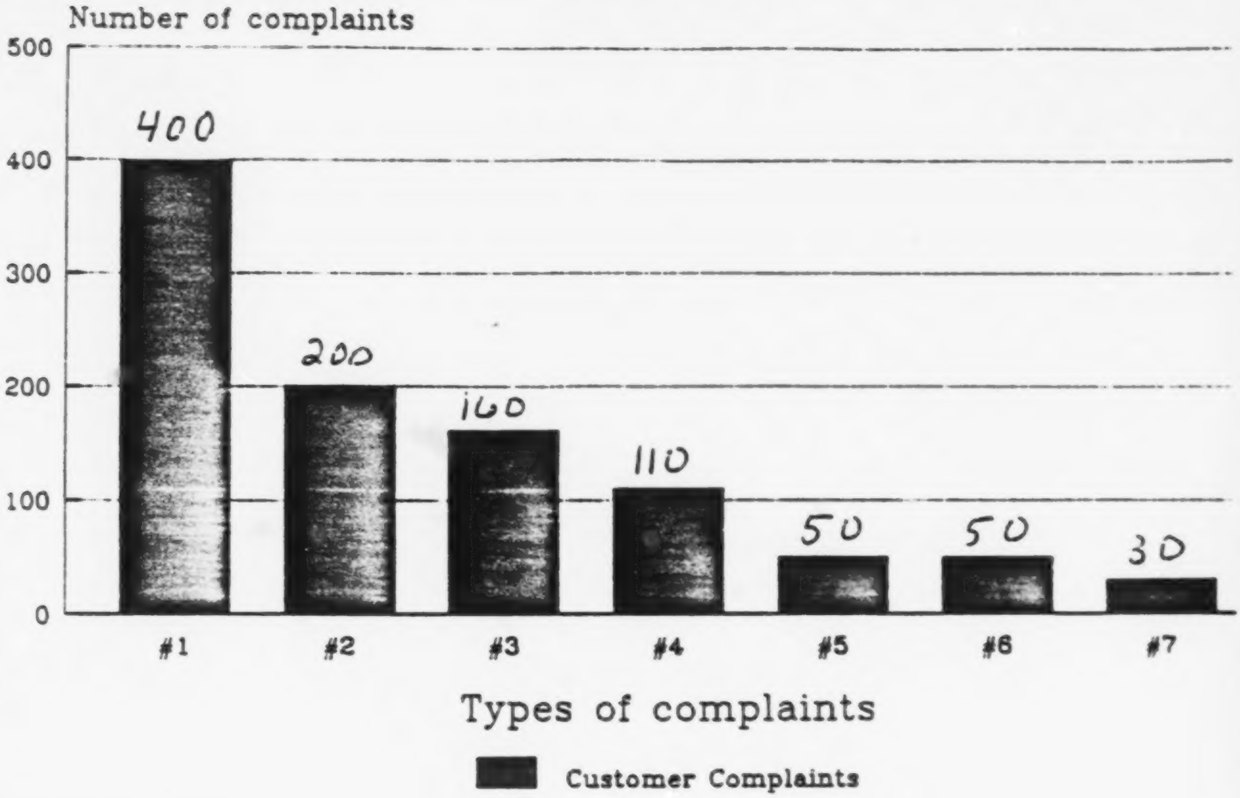


Total Complaints: 1000

- #1: Long wait for appointment
- #2: Inconvenient location
- #3: Impersonal service
- #4: Long wait for doctor
- #5: Lack of response to telephone calls
- #6: No pharmacy on premises
- #7: Noisy waiting room

Home Health Care Service

Customer Complaints



Total Complaints: 1000

#1: Long wait for appointment

#2: Inconvenient location

#3: Impersonal service

#4: Long wait for doctor

#5: Lack of response to telephone calls

#6: No pharmacy on premises

#7: Noisy waiting room

NOTE: This sample Pareto is provided to spark you into creating your own charts. Questions should be developed based on the needs of your individual students. This Pareto can also be used to reinforce 'mental math' skills.

Now that we have created charts for you, how about you taking a shot at it?!

NAME: ____________________

DATE: ____________________

I. M. TALL COMPANY

HEIGHT OF DAY-SHIFT WORKERS

STUDENT WORK SHEET

Directions: The heights the following day-shift workers of the I.M. Tall Company were measured. The results are in the table below. Using that data, construct a histogram on the next page.

Worker	1	2	3	4	5	6	7	8
Height	5'5''	5'1"	5'4"	5'2"	5'6"	5'8"	5'3"	5'9"
Worker	9	10	11	12	13	14	15	16
Height	5'4"	5'	5'2"	5'4"	5'7"	5'10"	5'5"	5'3"
Worker	17	18	19	20	21	22	23	24
Height	5'6"	5'3"	5'1"	5'6"	5'9"	5'7"	5'5"	5'5"
Worker	25	26	27	28	29	30	31	32
Height	5'6"	5'5"	5'4"	5'5"	5'7"	5'6"	5'8"	5'5"
Worker	33	34	35					
Height	5'5"	5'6"	5'4"					

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I. M. TALL COMPANY

HEIGHT OF DAY-SHIFT WORKERS

STUDENT WORK SHEET

I. M. TALL COMPANY
HEIGHT OF DAY-SHIFT WORKERS

STUDENT WORK SHEET

Directions: Answer the following questions based on the histogram on the previous page.

1. The heights of how many employees were measured? _______

2. What is the height of the shortest employee? ___________

3. How tall is the tallest employee? __________

4. How many employees are 5'7" tall? _________

5. This histogram represents a (bell-shaped, skewed, or bimodal) curve.

6. What is the R? _____________

7. What is the $\overline{X}$? _____________

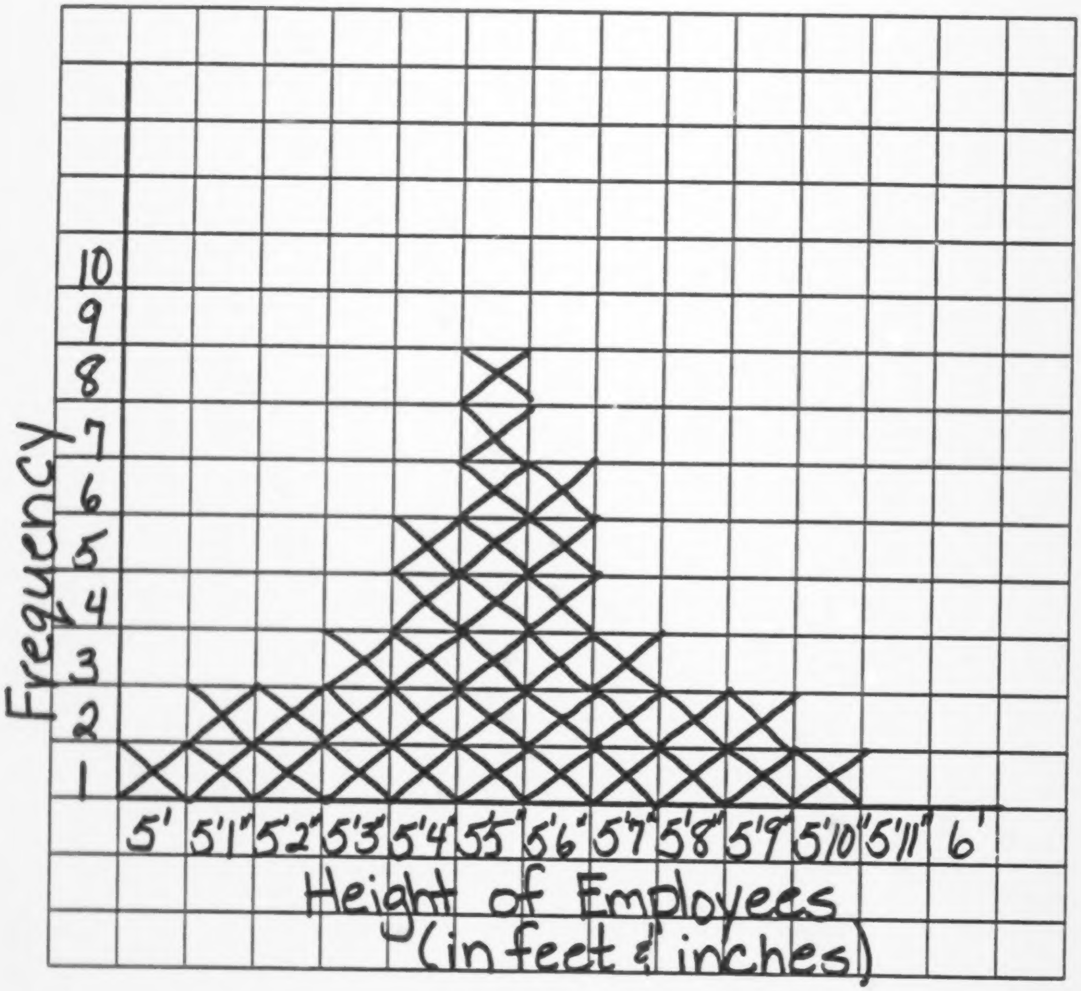
8. What is the mode? _____________

9. Does this histogram show normal or abnormal variation in employee height? _______________

I. M. TALL COMPANY

HEIGHT OF DAY-SHIFT WORKERS

TEACHER KEY



I. M. TALL COMPANY
HEIGHT OF DAY-SHIFT WORKERS

TEACHER KEY

Directions: Answer the following questions based on the histogram on the previous page.

1. The heights of how many employees were measured? **35**

   Students should recognize that each X represents the height of one employee.

2. What is the height of the shortest employee? **5'**

   Students can determine this answer simply by looking at X furthest to the right on the histogram. You may want to review what the x axis and the y axis represent.

3. How tall is the tallest employee? **5'10"**

   Similarly, students can determine this value by looking at the X furthest to the right on the histogram.

4. How many employees are 5'7" tall? **3**

   This answer can easily be determined by locating the top X in the 5'7" column and looking across to the y axis where the frequency of that value is noted. If students have trouble with this, you may need to review coordinates and calibration material in Appendix .

5. This histogram represents a (**bell-shaped**, skewed, or bimodal) curve.

   If students have difficulty identifying which type of curve this histogram has, refer to the chapter on histograms for illustrations.

I. M. TALL COMPANY
HEIGHT OF DAY-SHIFT WORKERS

6. What is the R? **10"**

The range is calculated by subtracting the highest height from the lowest height:

```
  5'10"
- 5'
 ______
    10"
```

7. What is the $\bar{X}$? **5'4"**

Calculating the mean or average is a bit more complicated than the range. To facilitate this exercise, we suggest you follow these steps:

1. Change all the heights from feet & inches to inches only.
2. Find the total number of inches with the aid of a calculator.
3. Divide the total by 35
4. Change you answer to feet & inches once again.

8. What is the mode? **5'5"**

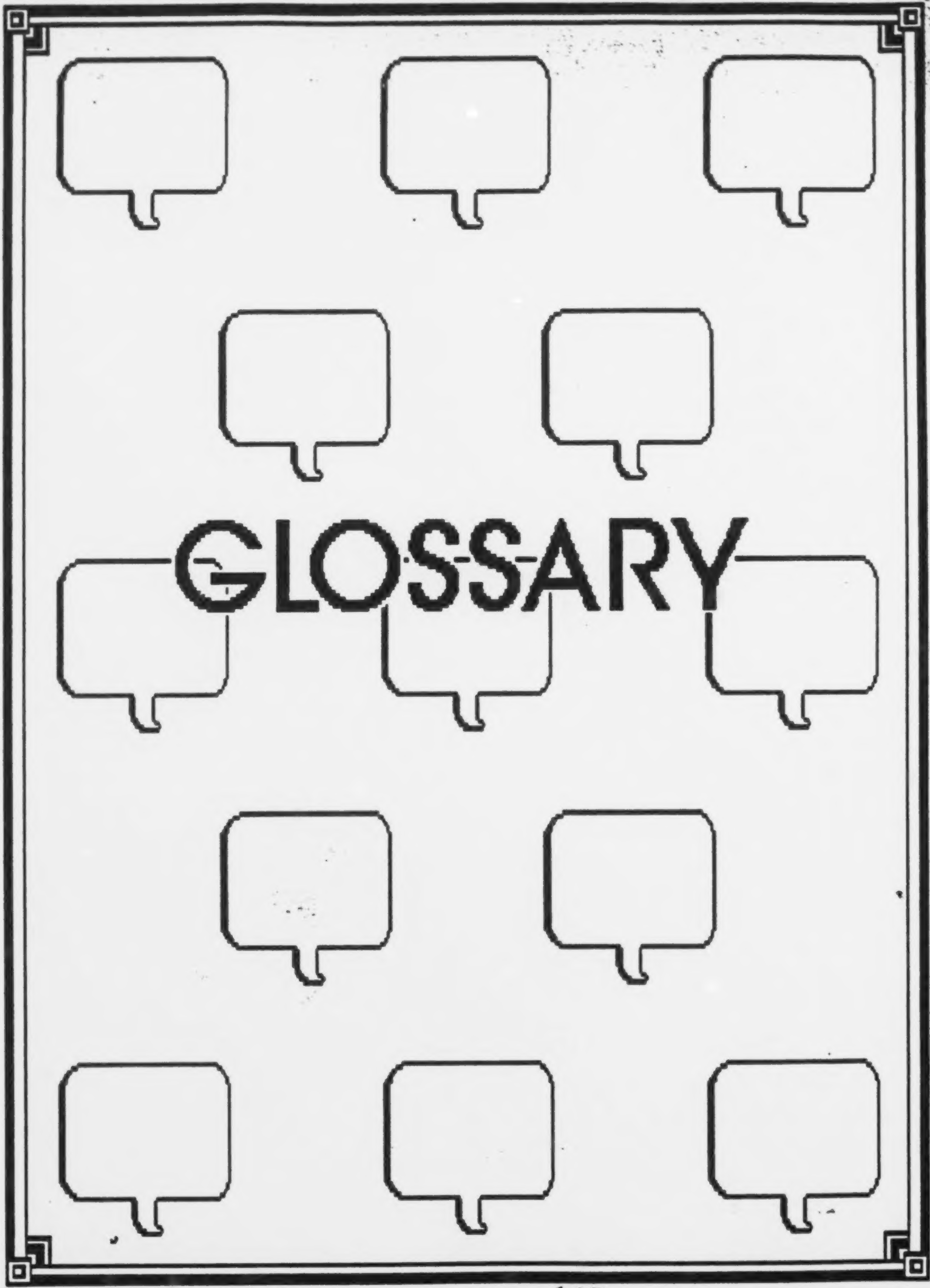
The mode is that value which appears most frequently. (If you need a refresher, see the section discussing "mean, median, mode")

9. Does this histogram show normal or abnormal variation in employee height? **normal**

The definition of a normal distribution is:

1. The majority of points are at the center.
2. There are an equal number of points above and below the center.
3. As you move away from the center there are fewer and fewer points.
4. The points show a continuous bell-shaped curve.

GLOSSARY



GLOSSARY

cause-and-effect diagram: (also known as cause-and-effect analysis) A method used to identify all the possible causes of a problem, eventually seeking the root cause. This method is normally a group process, often incorporating brainstorming strategies.

central tendency: The measure of the center of a set of data. There are three measures of central tendency: **mean, median**, and **mode**.

common causes: The normal factors that are always present in a process. Common cause has minimal effect on the total variation.

control chart: A graphical method for determining whether a process is in statistical control. A line graph is used to show the variation in a process. Generally, a control chart has upper and lower control limits to monitor variation. There are several types of control charts, each designed to monitor, but not analyze, the variation in a process.

countable data: (sometimes called **attribute** or **discrete data**) Data that is counted; it is always written as a whole number. This data cannot be measured on a scale.

cum line: (abbreviated form of **cumulative** line) A series of connected points plotted on top of each bar on a Pareto chart. The points tell us how the total percentage of each category builds upon the previous category until 100% is reached.

distribution: The spread of data. A curve can be placed around the heights of the bars of a histogram to establish its general shape; this curve is often called the distribution, or frequency distribution.

frequency distribution: Same as a histogram, but with the curve outlining the bars added.

histogram: A bar chart typically displaying measurable data; it shows us variation in the data, or how the data is distributed.

lower control limits (LCL): The lower limits of a variation. Both the lower and upper control limits are considered the boundaries of the variation. As long as the plotted points on the control chart fall between the upper and lower control limits and form a random pattern, the process is considered in statistical control. The control limits are based on the actual performance of a process. Often, the control limits are drawn at values three standard deviations from the mean line. There are occasions, however, when the lower limits are set at zero instead (since negative values are not used).

mean: (represented by the symbol X) A measure of central tendency; it is the sum of all the values in a group divided by the number of items in the group.

median: A measure of central tendency; it is the value that falls in the middle of a set of ordered measurements. For example, the median of the set of data: 4, 8, 2, 7, and 9 is 7 (not 2) because if the data was arranged in order, the middle number would be 7 (2, 4, 7, 8, 9).

mode: A measure of central tendency; it is the value occurring most frequently in a set of data. On a histogram, it would be the highest bar. For example, the mode for the set of data: 4, 3, 5, 6, 7, 2, 7, 8, and 1 is 7 because the numeral 7 occurs most often in the set of data.

normal distribution: A symmetrical, bell-shaped curve generally expected when a process is running normally.

normal variation: Variation occurring naturally. A process that has normal variation has only common causes present and is in statistical control.

Pareto chart: A special bar chart that shows the arrangement of data in order of importance (from left to right).

process control: The control of a process by eliminating all of the special causes of variation. When a process is functioning in "statistical control", only common causes of variation are present. Process control monitors the process, signaling when special causes of variation are present. Statistics are most often used to monitor the process.

quality: According to the American Society for Quality Control, it is "the totality of features and characteristics of a product or service that bear on its ability to satisfy given needs". Quality is also considered "the achievement of excellence in a service or product".

range: The difference between the highest and lowest values of a group; for example, in this group of data: 5.4" , 6.7", 4.9" , 4.8", and 6.5", the range is 1.9" (6.7 -4.8).

SPC (Statistical Process Control): A method of controlling a process using statistics. If a process is in statistical control, only common causes are present. A process in statistical control is NOT a guarantee that it is producing a quality product.

special causes The factors that cause excessive variation; special causes need to be checked out since they cause a process to be out of statistical control. For example, if a machine needs oiling and thus begins vibrating to the point of producing poor quality products, the process needs to be stopped and the machine repaired.

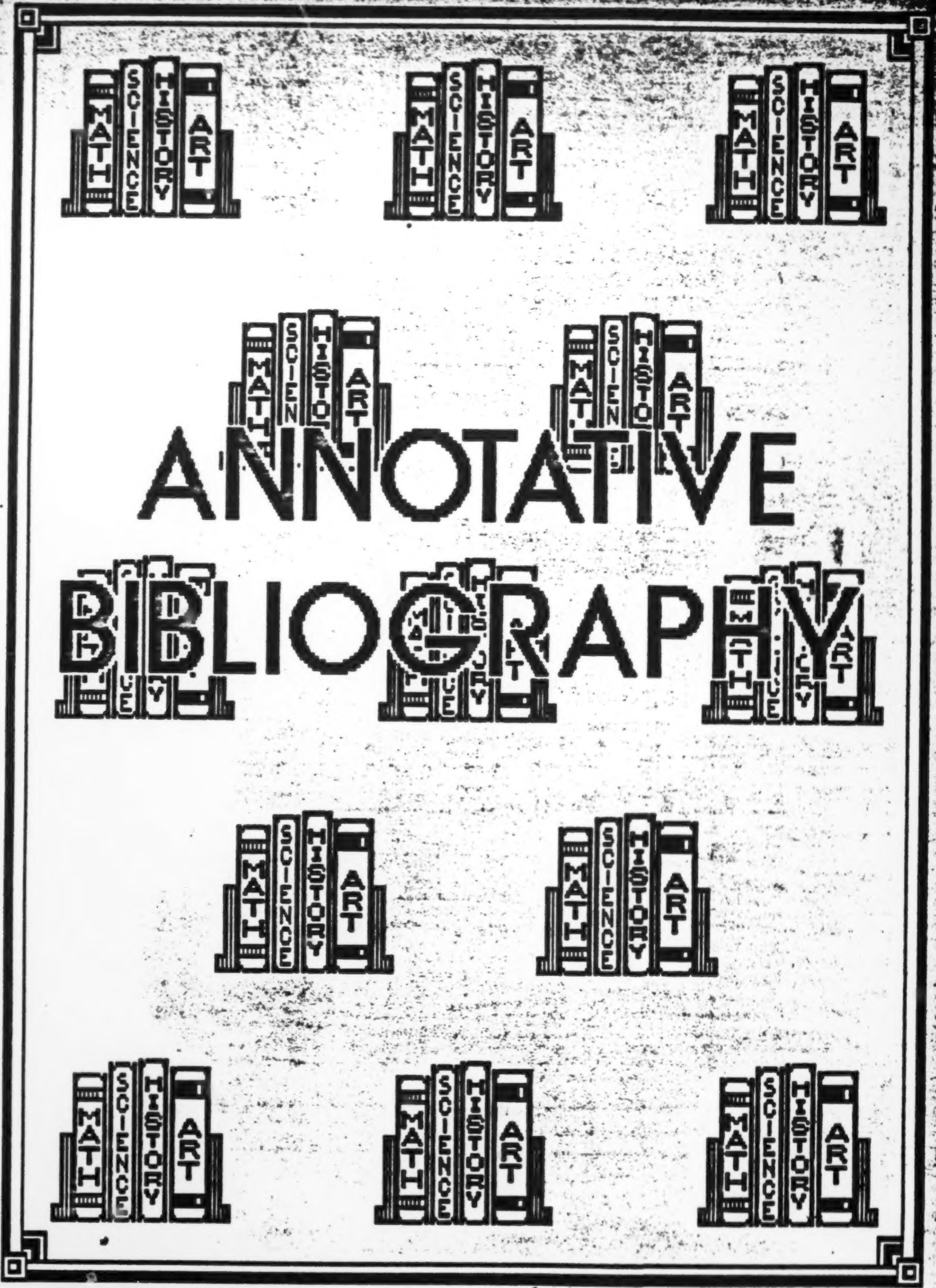
upper control limits (UCL): See **lower control limits.**

variable: A part of a process that can be counted or measured. For example, workplace education programs tend to evaluate programs based on the number of students and/or the number of hours each student participates in a program. Each of these, the number of students and the number of hours, is considered a variable.

variable data: (sometimes known as **measurble** or **continuous data)** Data that is measured, such as height, weight, time, and temperature. Unlike countable data, it is not expressed as a whole number.

variation: The differences that occur in products or processes.

ANNOTATIVE BIBLIOGRAPHY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